Demonstrate Zernike Ordering

February 28, 2019

1 Demonstrate Zernike Ordering

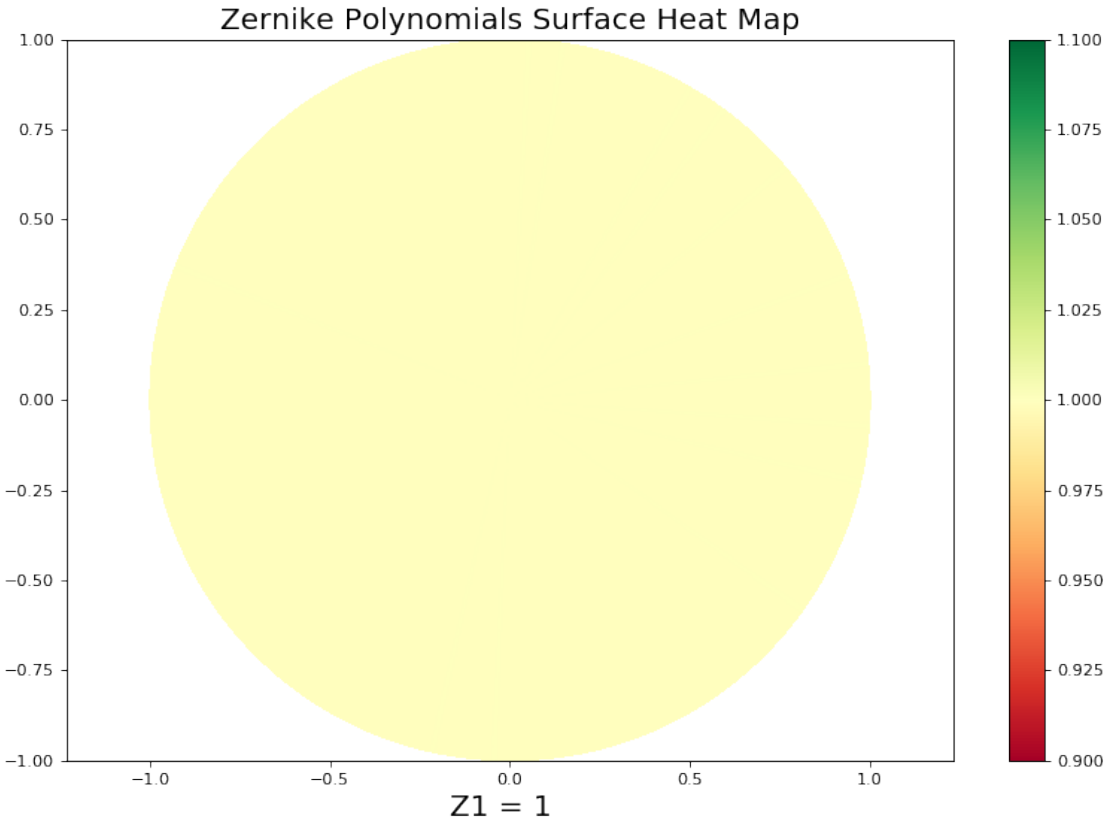
Use the opticspy package to demonstrate how we can convert from one zernike ordering to the other.

In [1]:
```
# import what we need
# %matplotlib inline
import opticspy
from zernikeIndexing import *
```

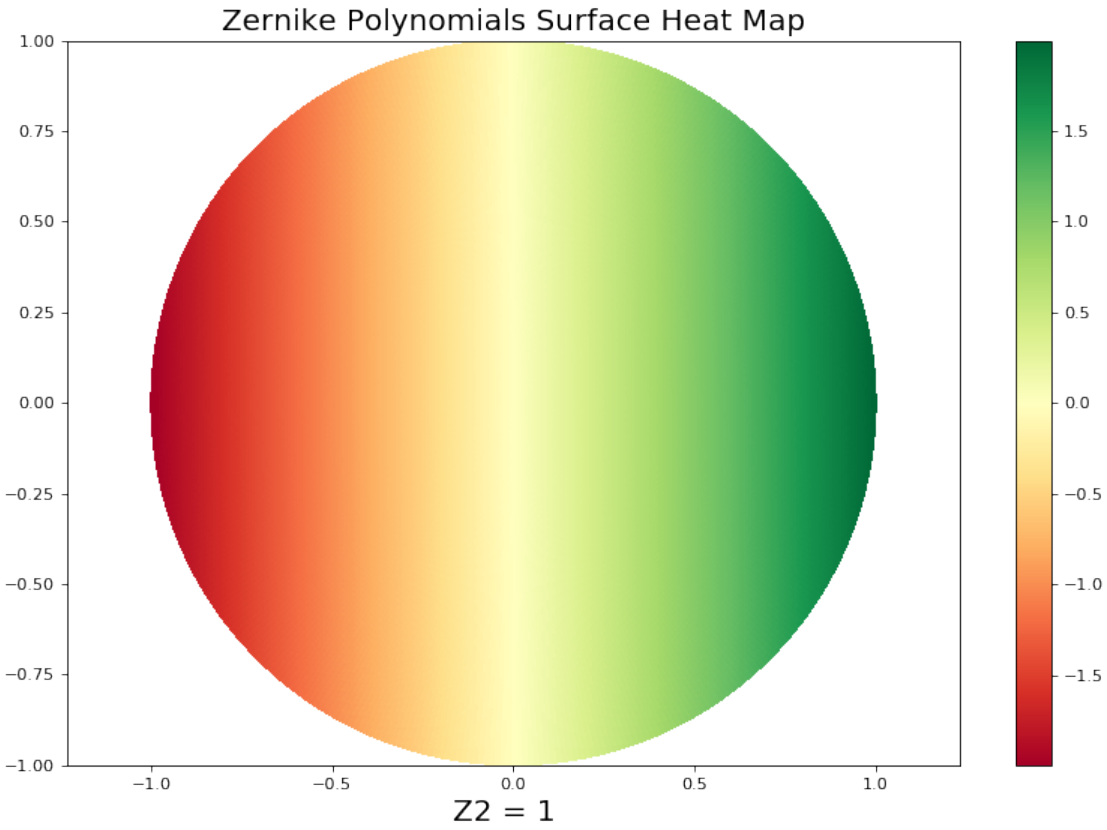
In [2]:
```
# generate the first 36 zernikes in noll ordering (used by opticspy)
zis = range(1, 37)
zs = []
for zi in zis:
    kwgs = {'Z%d' % zi: 1}
    zs.append(opticspy.zernike.Coefficient(**kwgs))
```

In [3]:
```
# plot them
for z in zs:
    z.zernikemap()
```

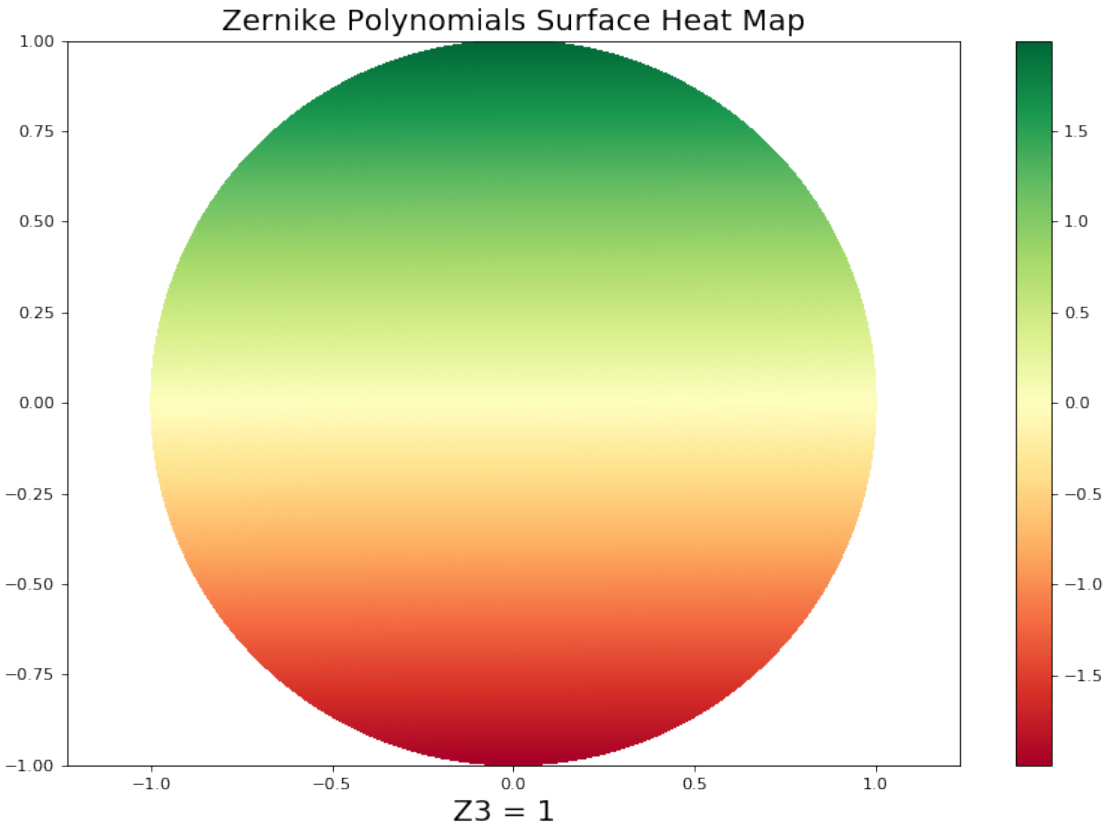
```
Z1 =  1 Z00 Piston or Bias
```



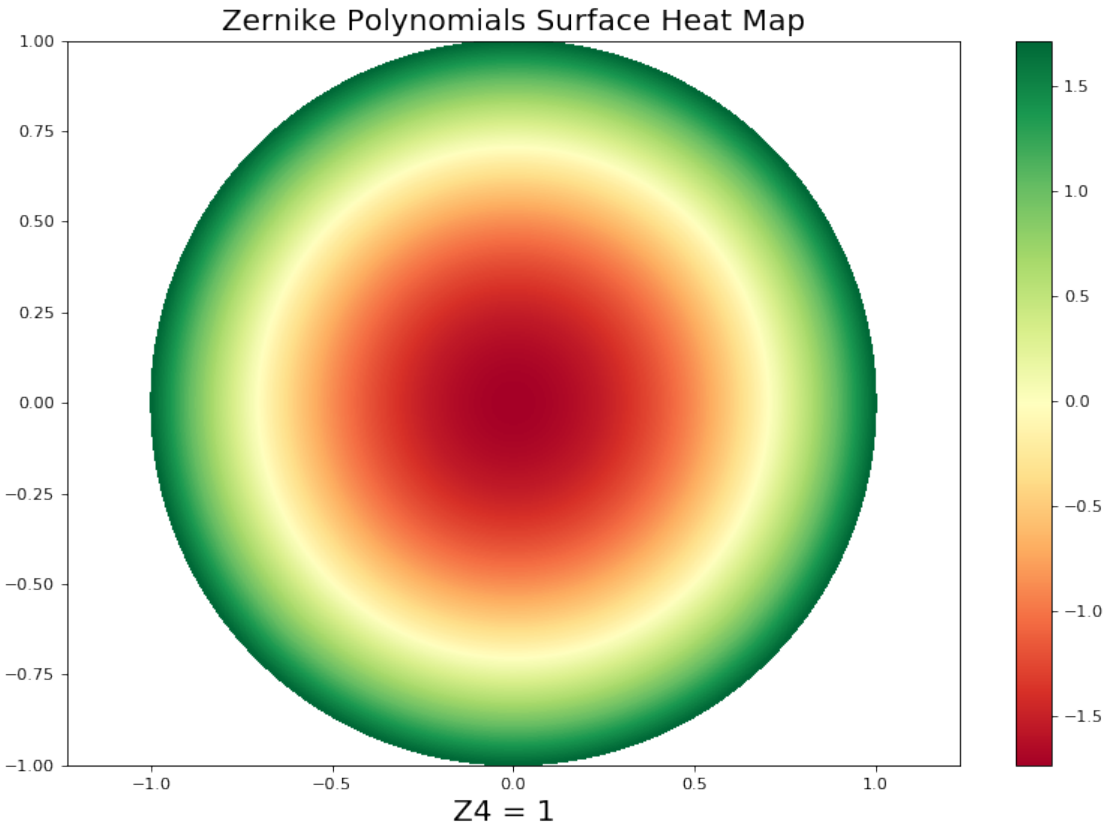
Z2 = 1 Z11 x Tilt



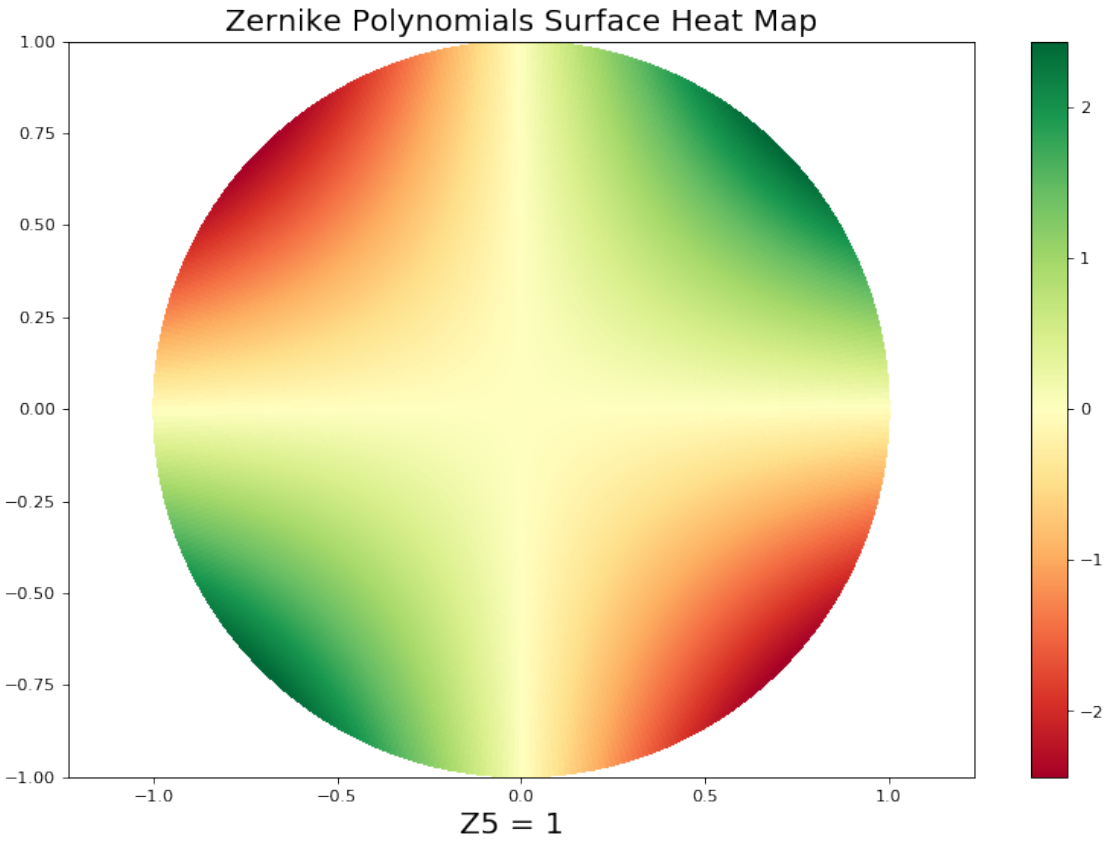

```
Z3 =  1 Z11 y Tilt
```



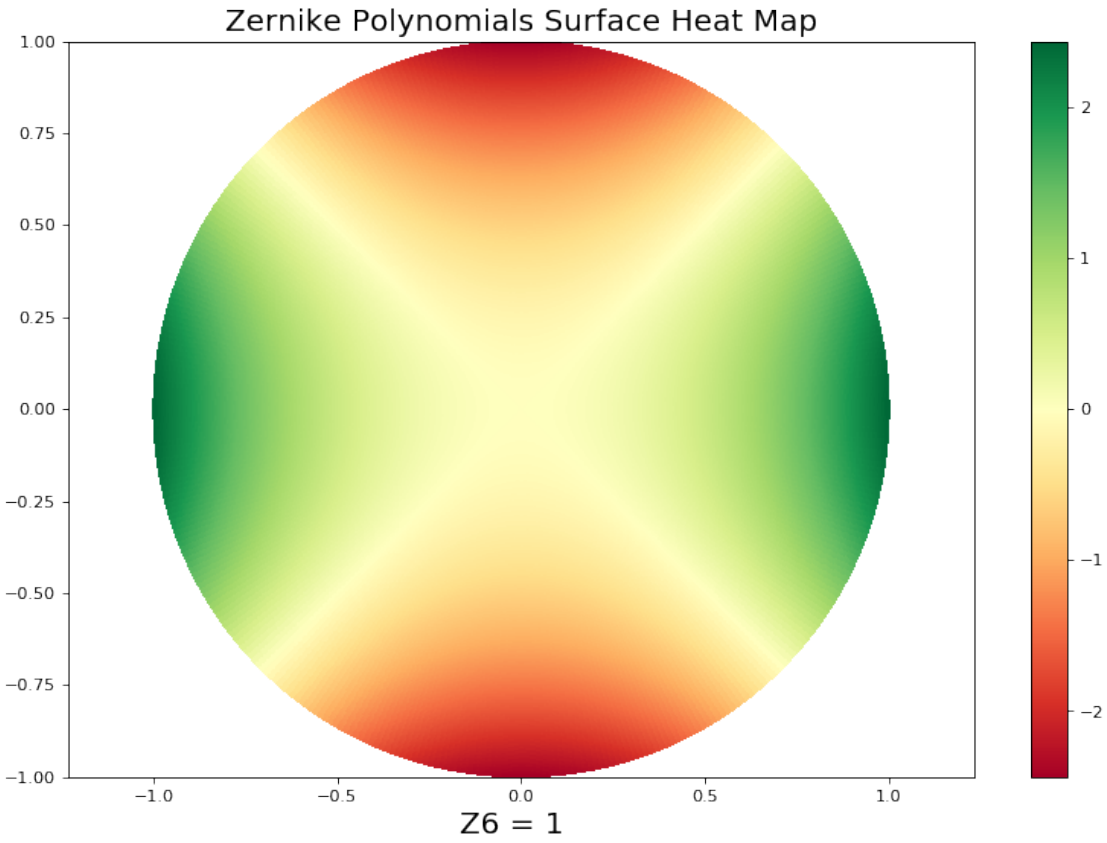

```
Z4 =  1 Z20 Defocus
```



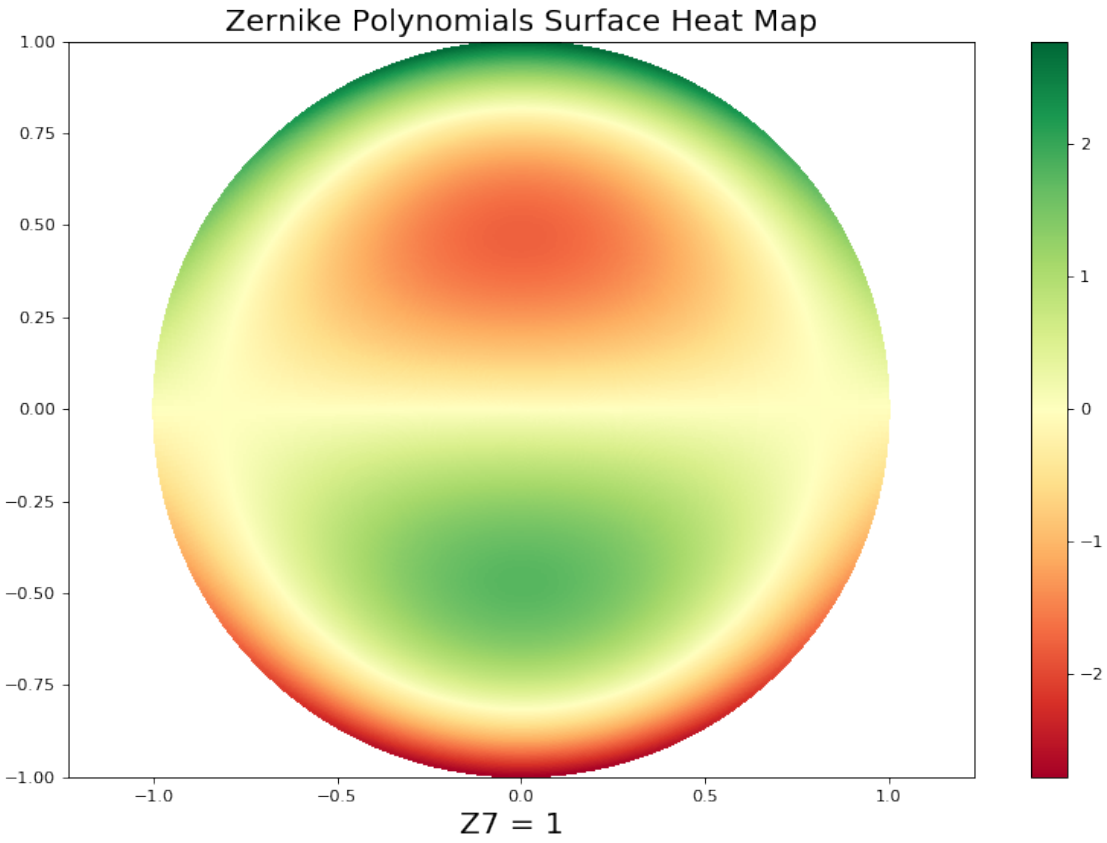
Z5 = 1 Z22 Primary Astigmatism at 45



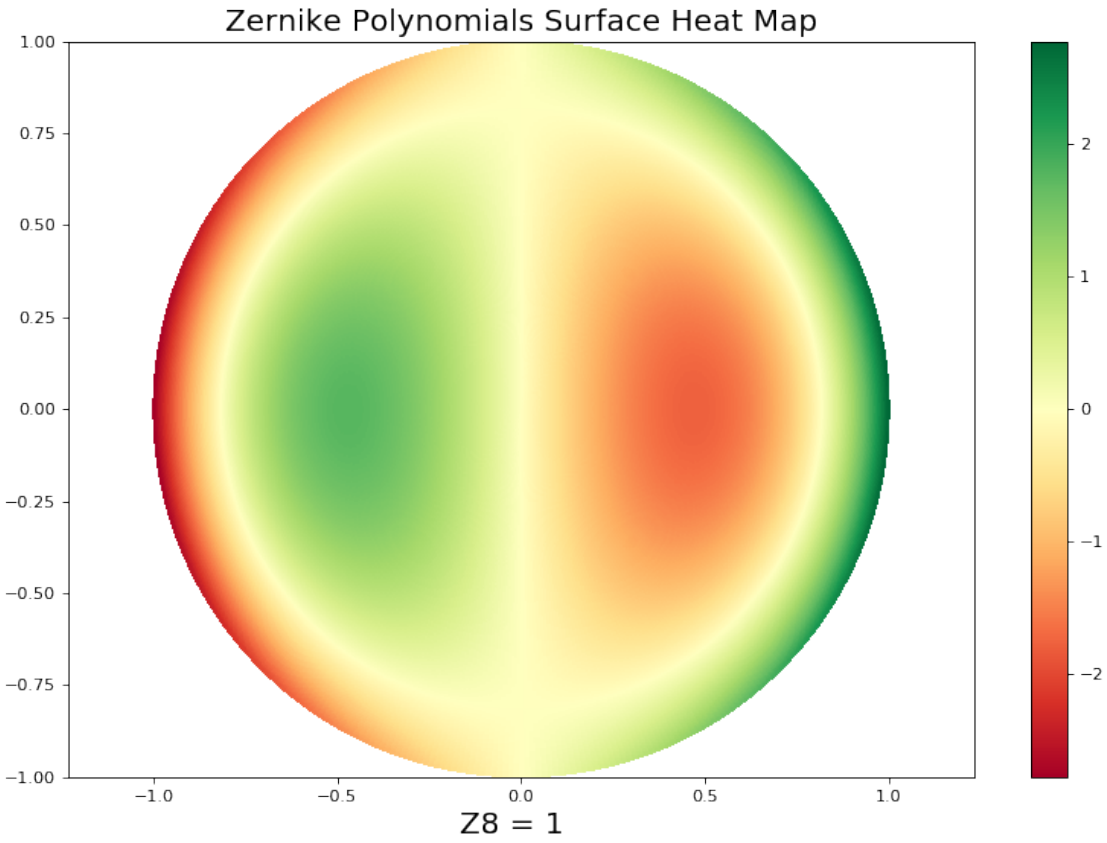
Z6 = 1 Z22 Primary Astigmatism at 0



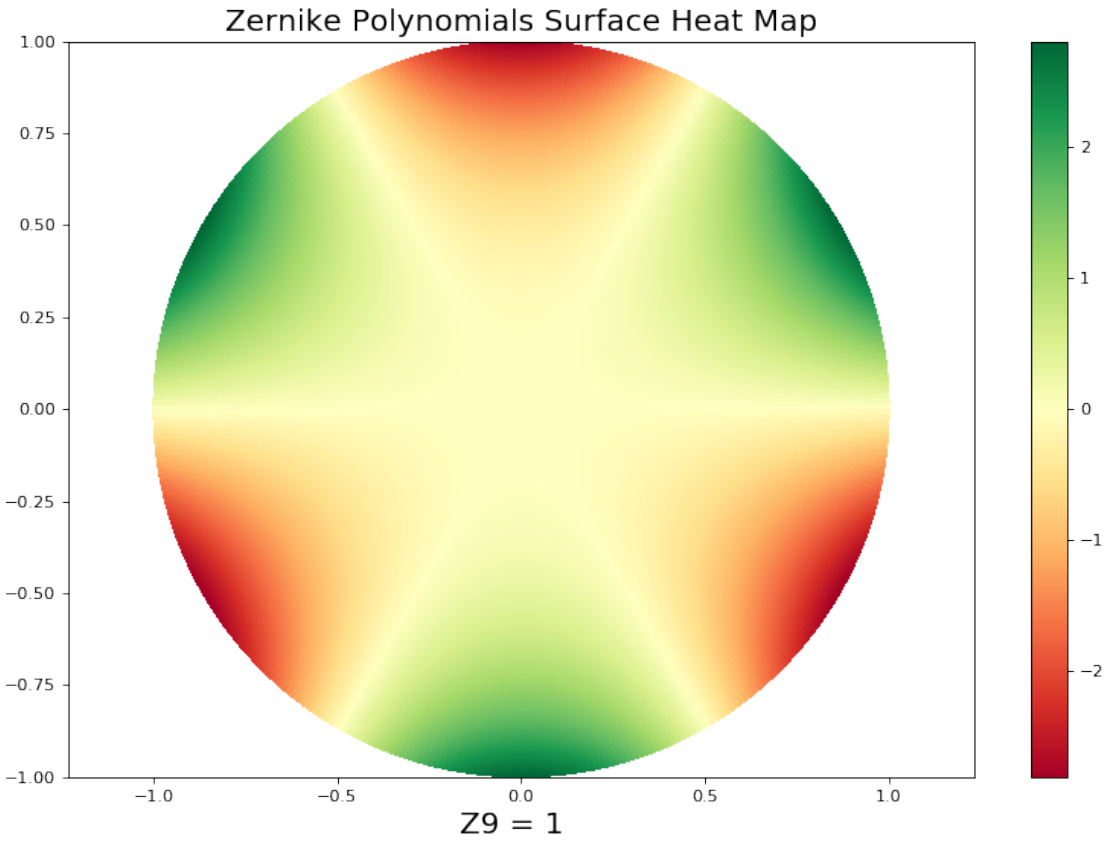
Z7 = 1 Z31 Primary y Coma



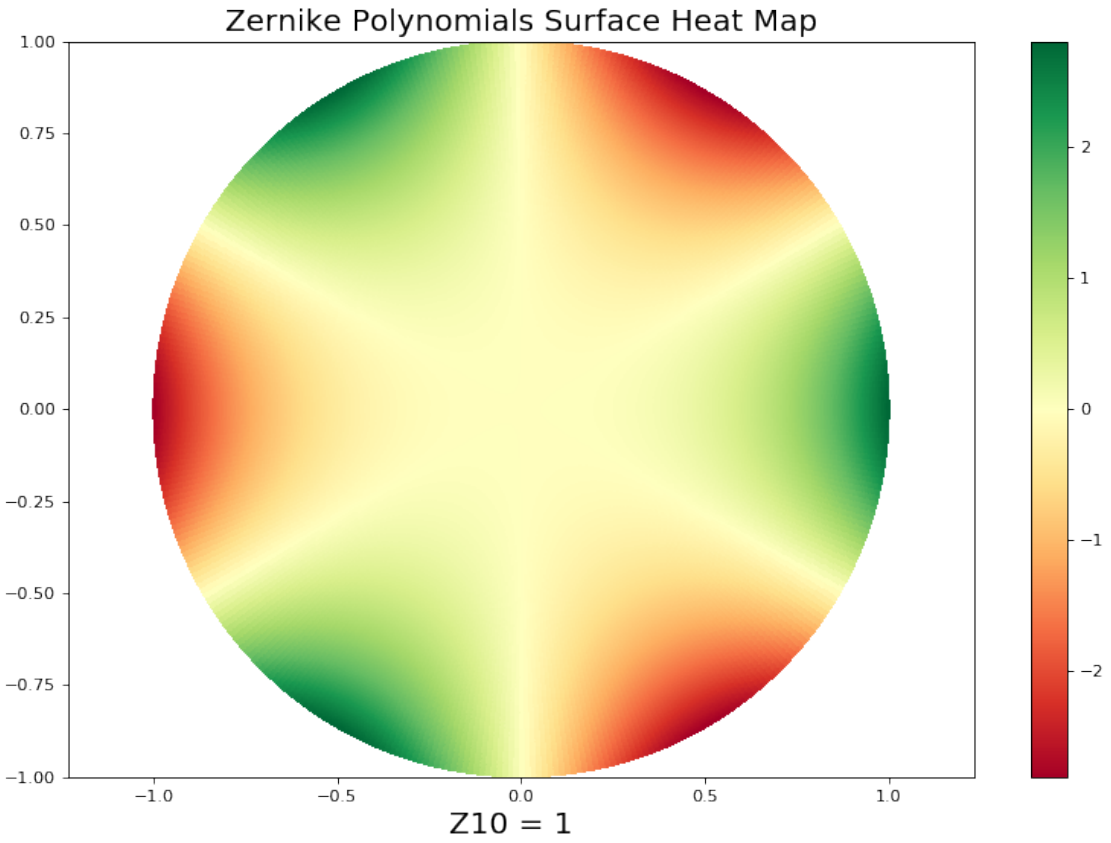

```
Z8 =  1 Z31 Primary x Coma
```



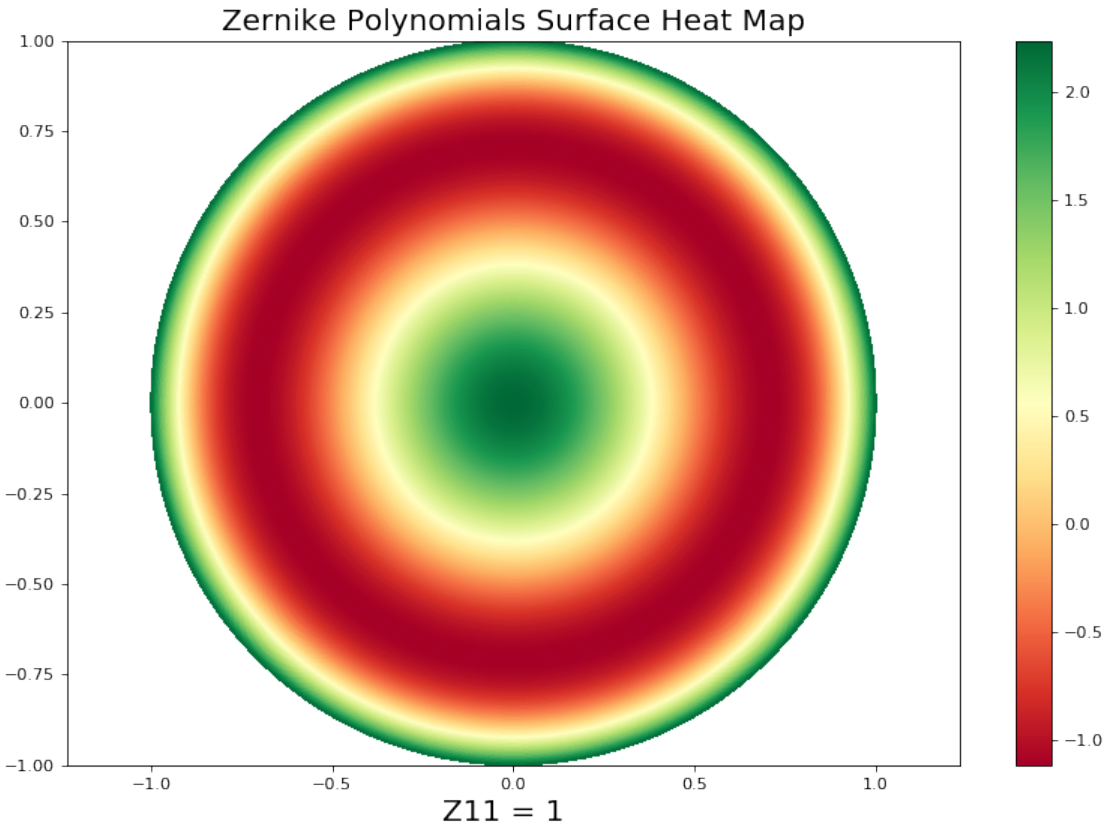
Z9 = 1 Z33 y Trefoil



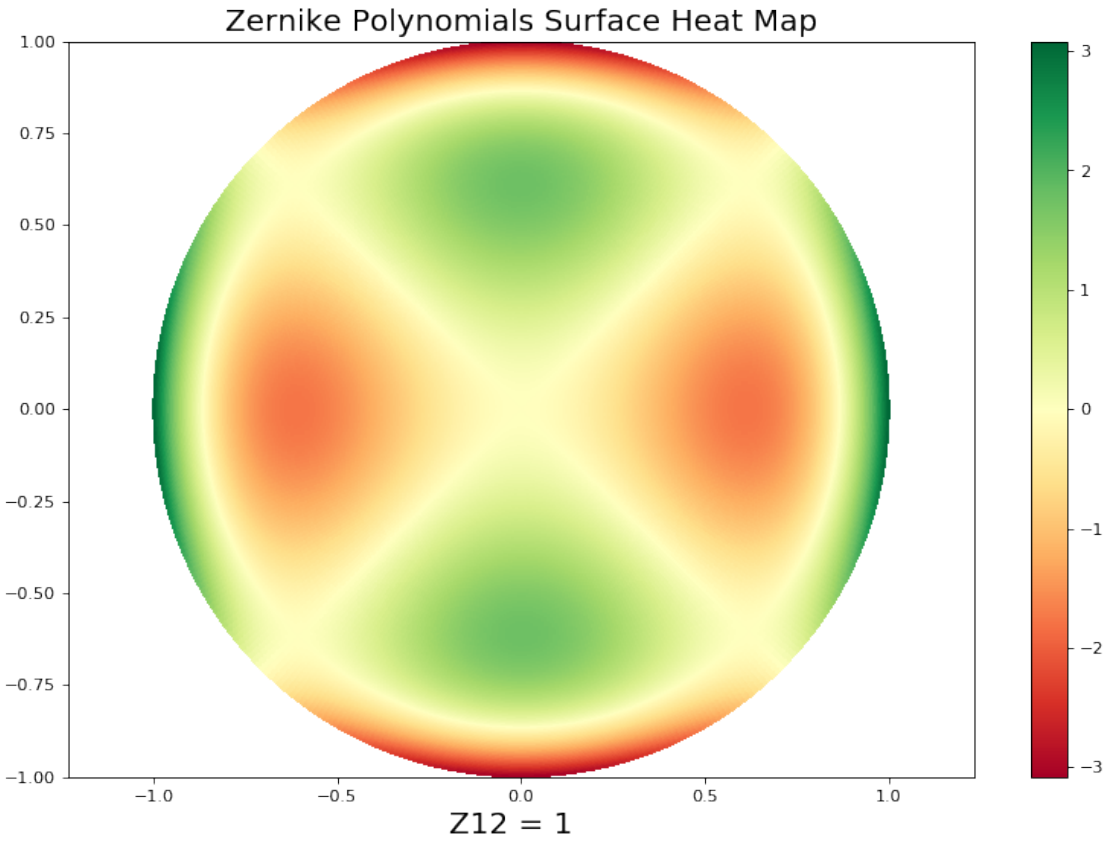
Z10 = 1 Z33 x Trefoil



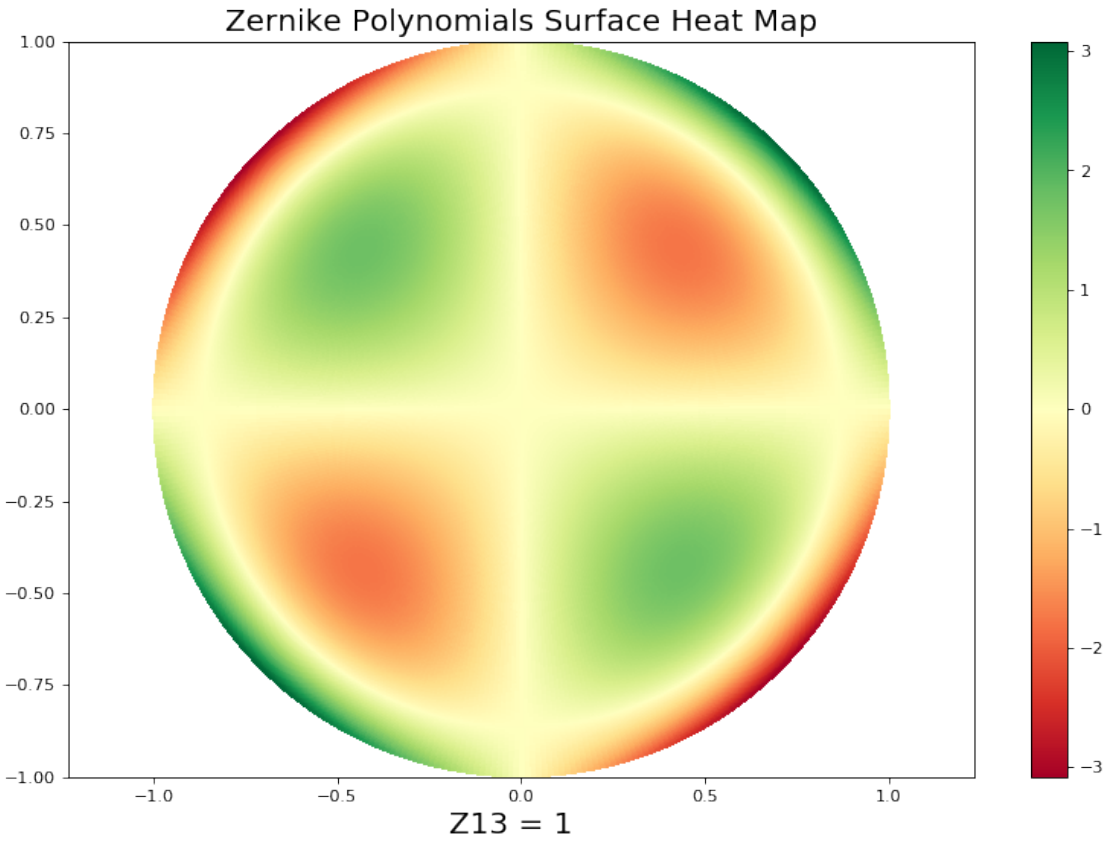
Z11 = 1 Z40 Primary Spherical



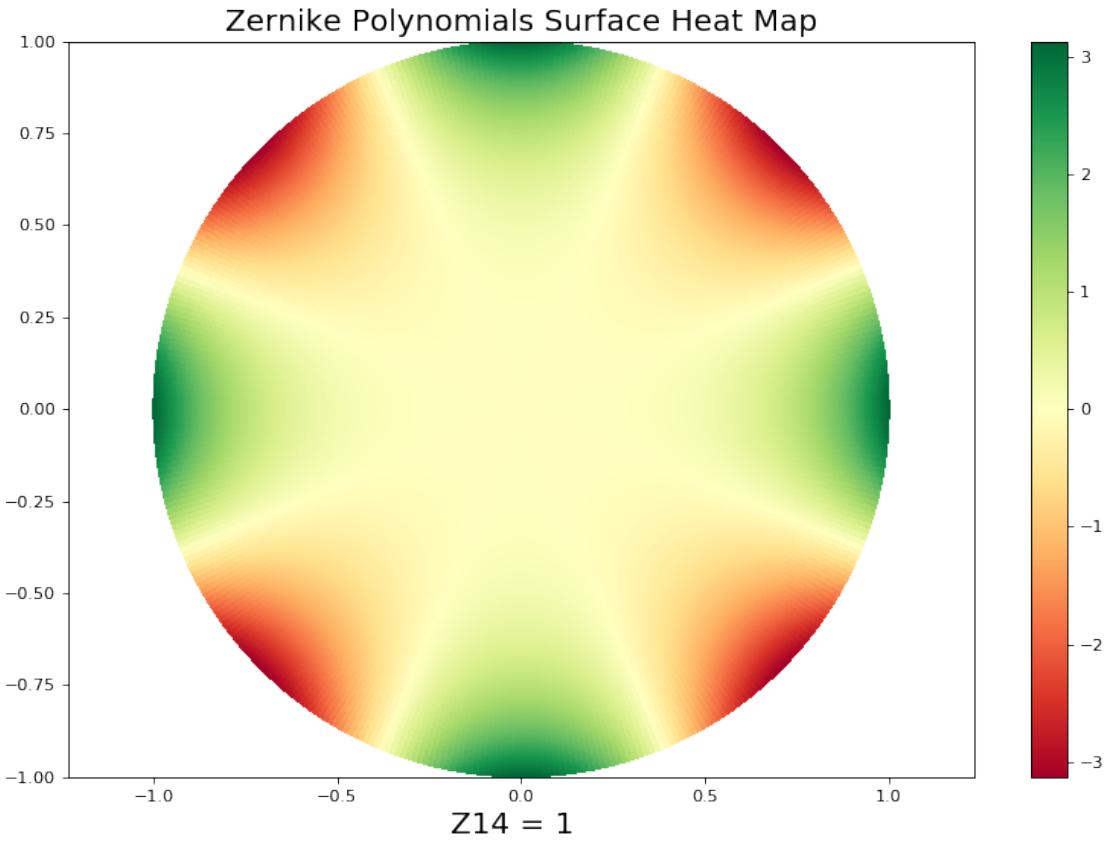
Z12 = 1 Z42 Secondary Astigmatism at 0



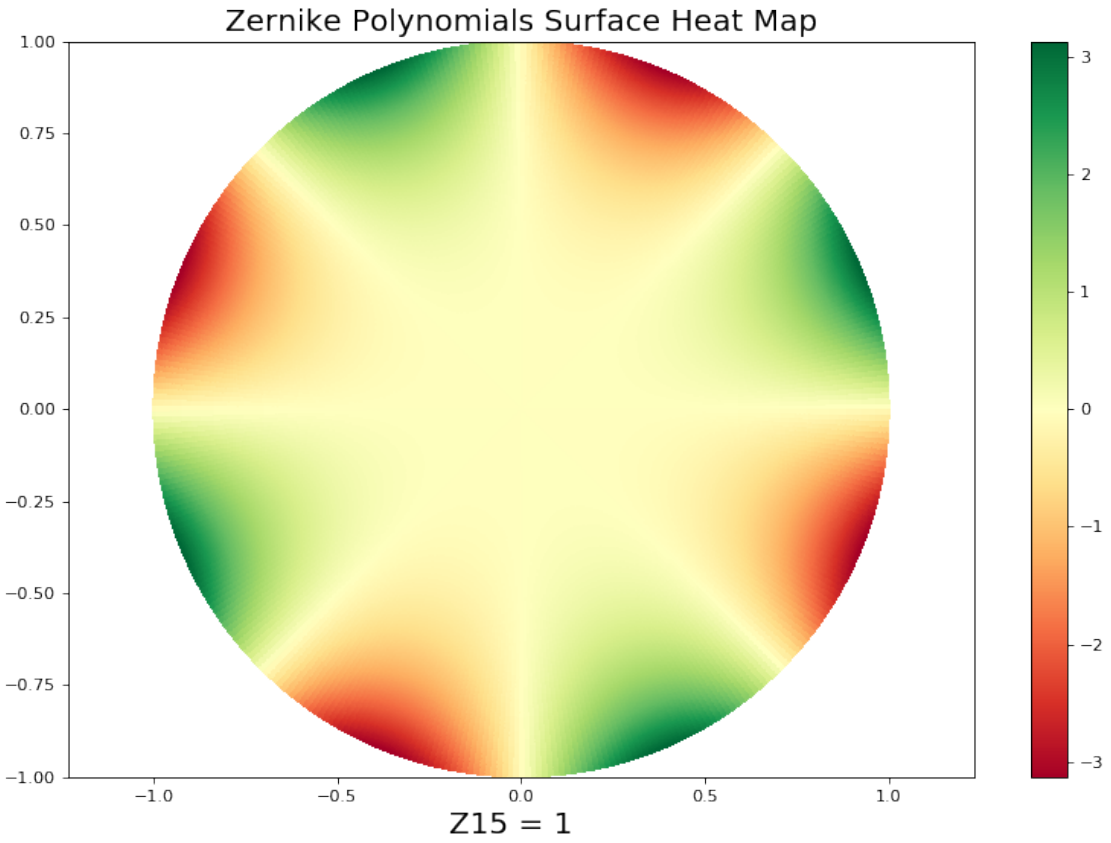
Z13 = 1 Z42 Secondary Astigmatism at 45



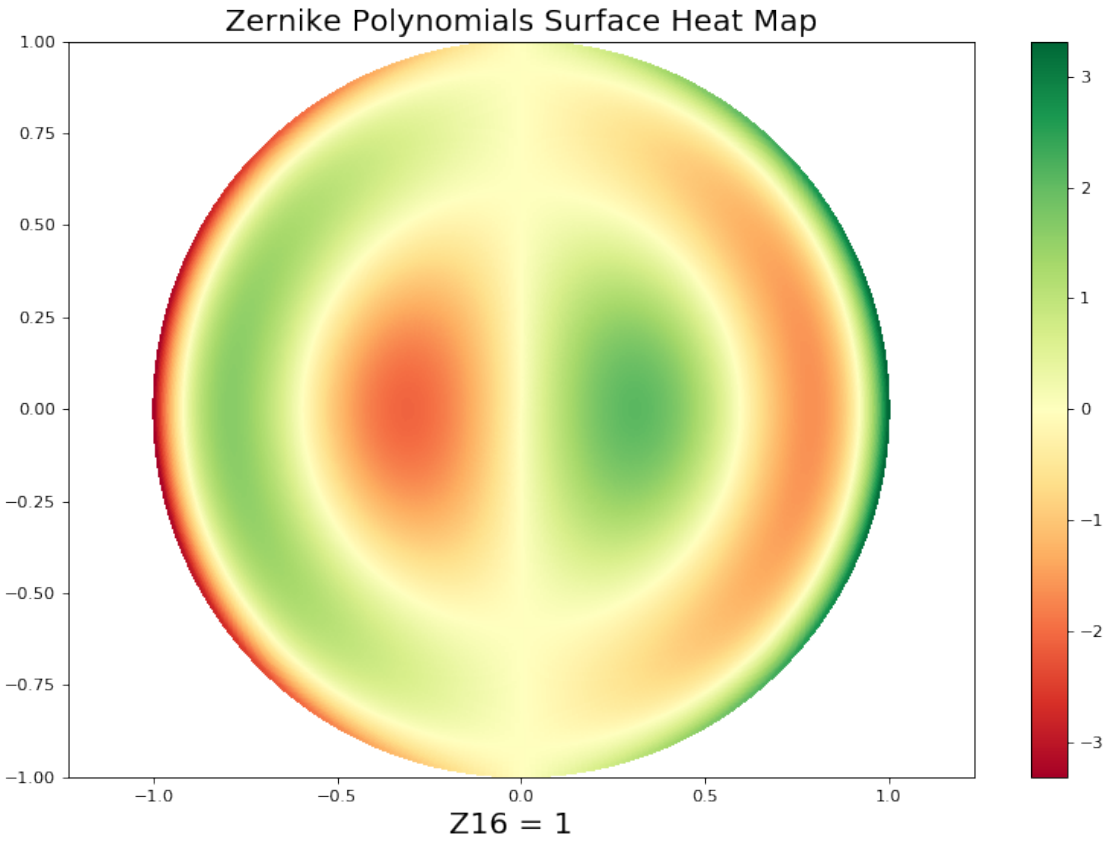
Z14 = 1 Z44 x Tetrafoil



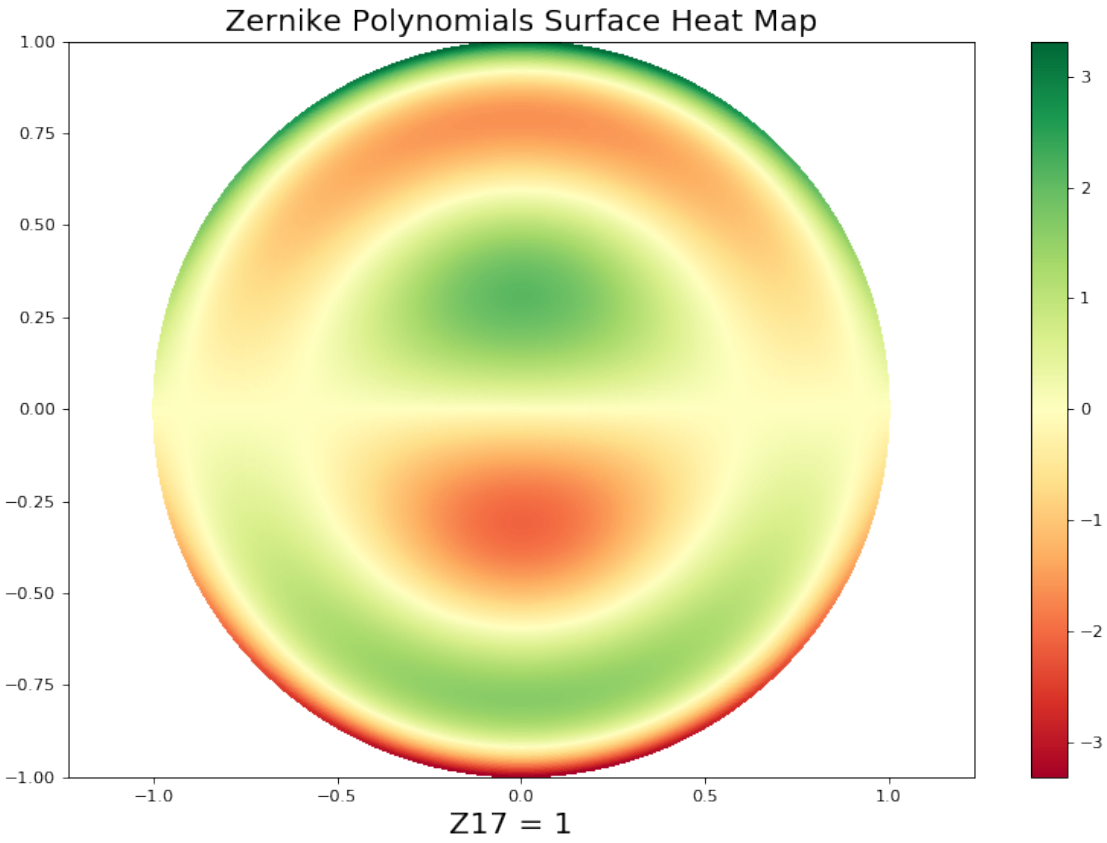
Z15 = 1 Z44 y Tetrafoil



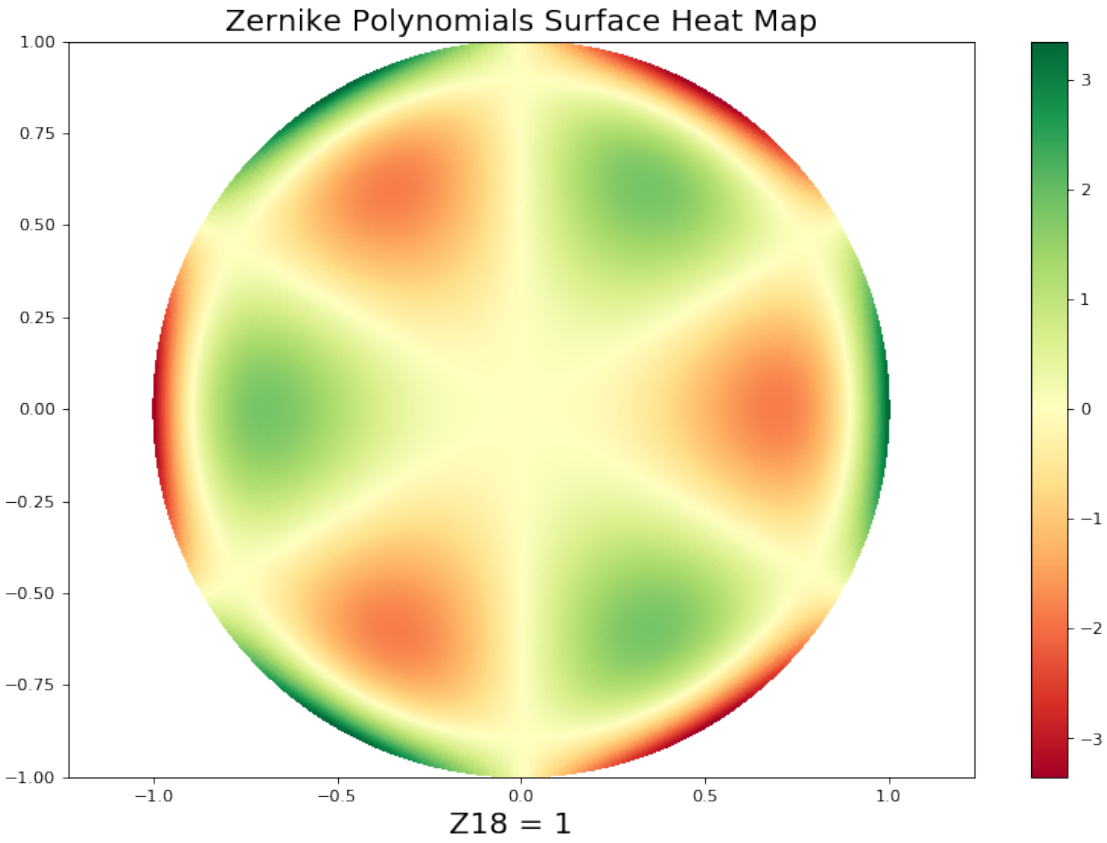
Z16 = 1 Z51 Secondary x Coma



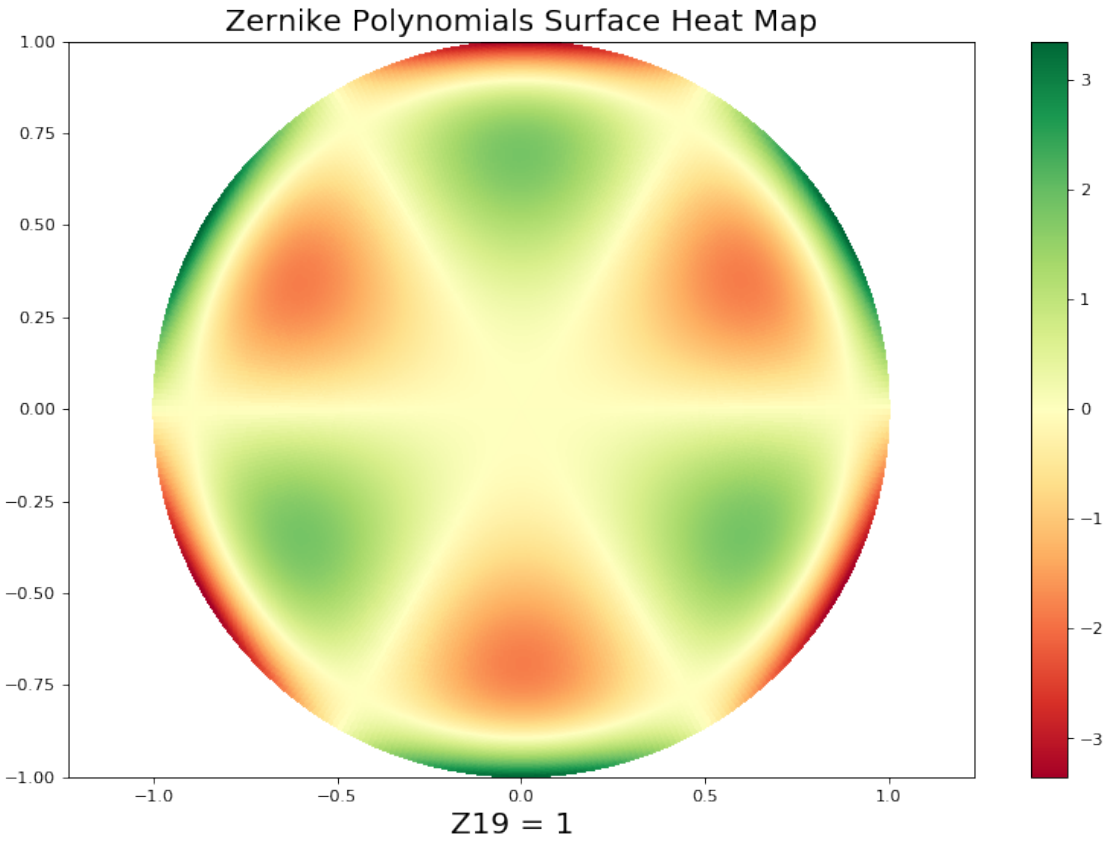
Z17 = 1 Z51 Secondary y Coma



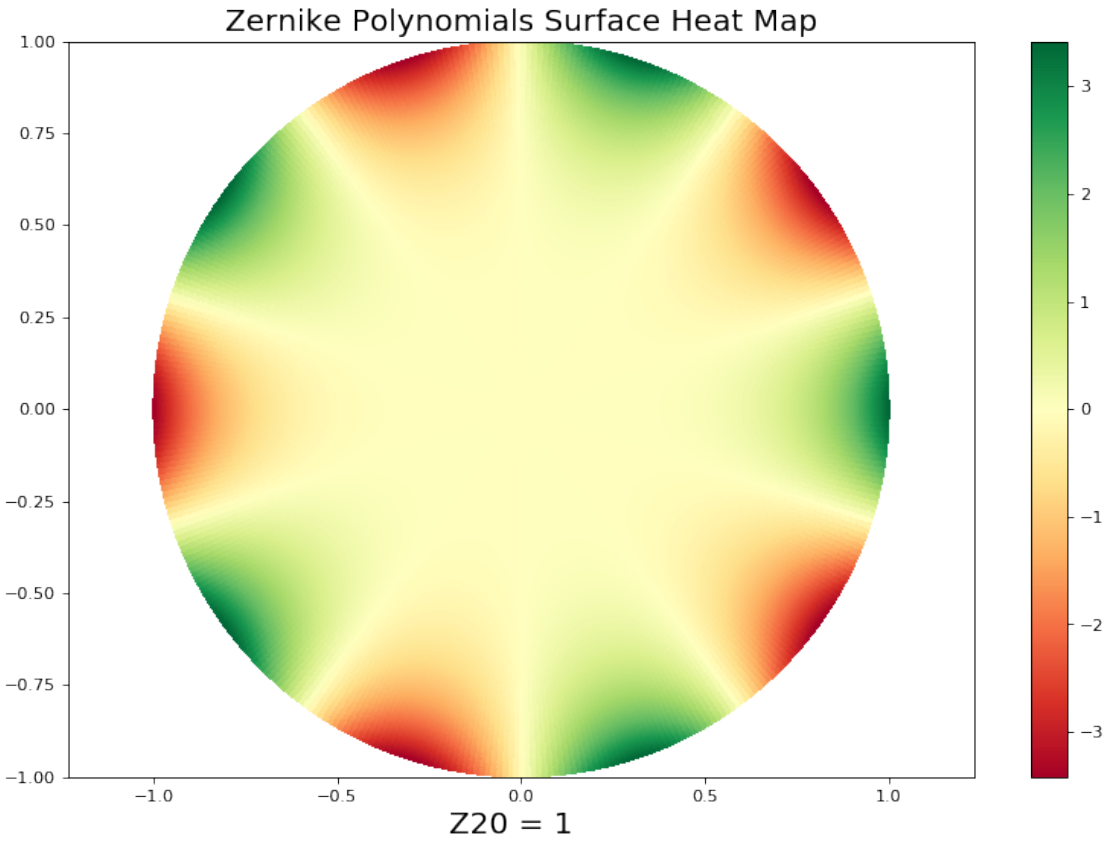
Z18 = 1 Z53 Secondary x Trefoil



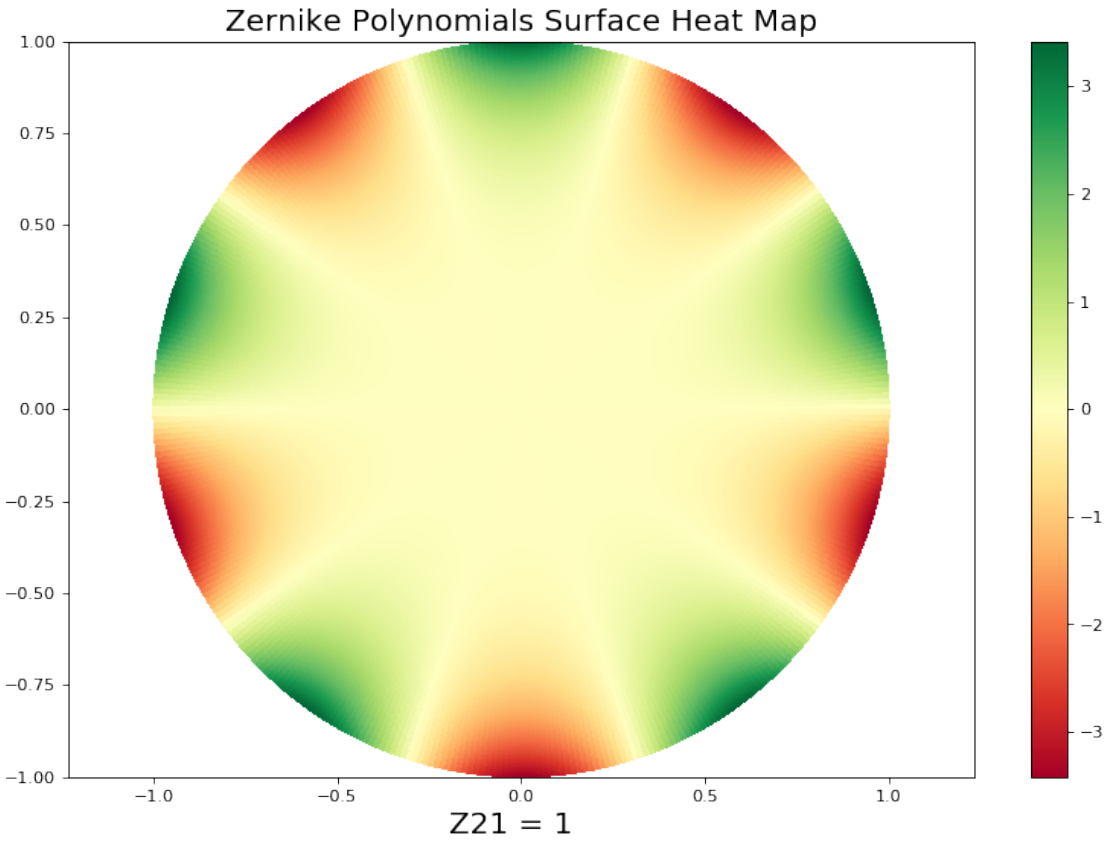
Z19 = 1 Z53 Secondary y Trefoil



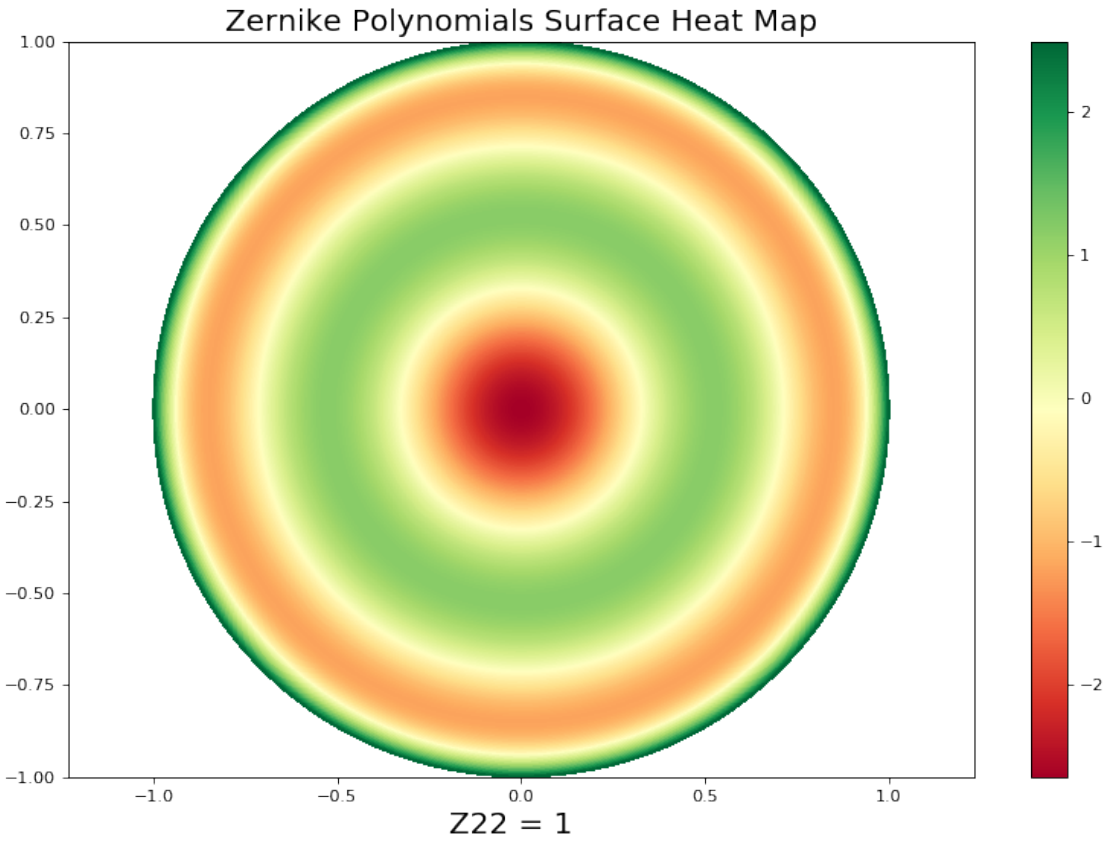
Z20 = 1 Z55 x Pentafoil



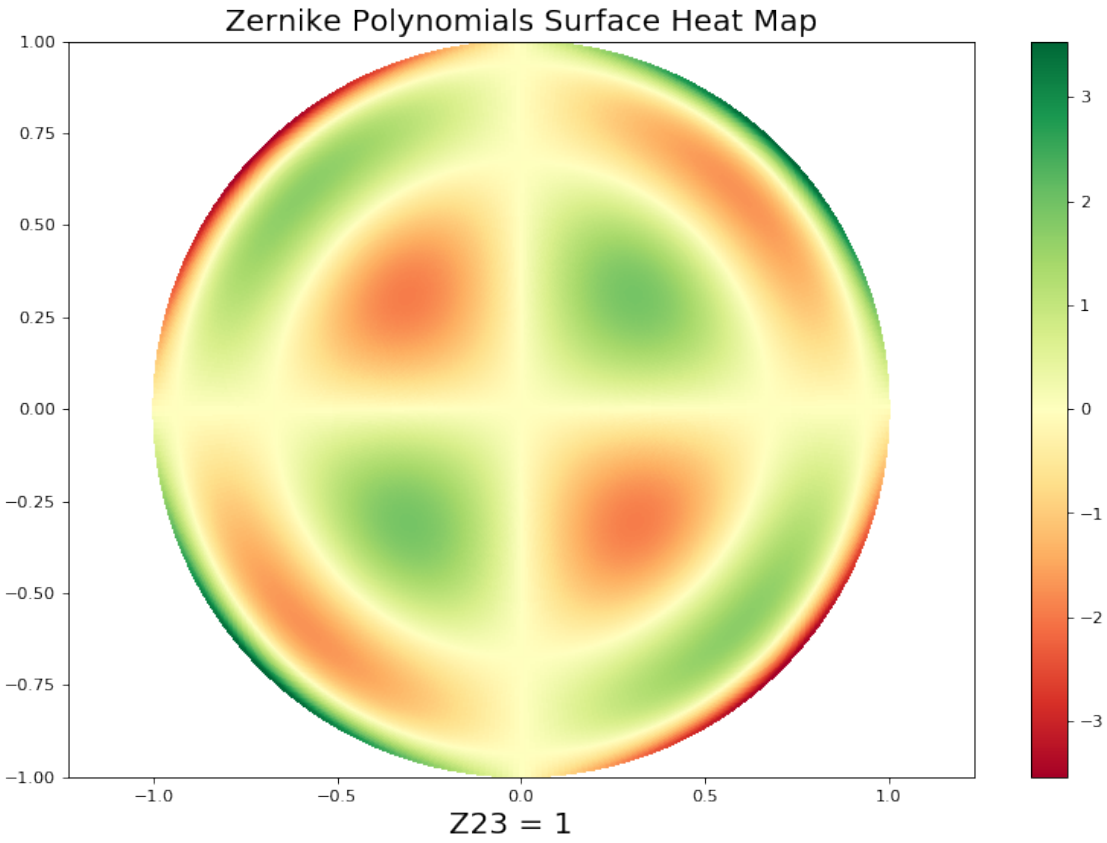
Z21 = 1 Z55 y Pentafoil



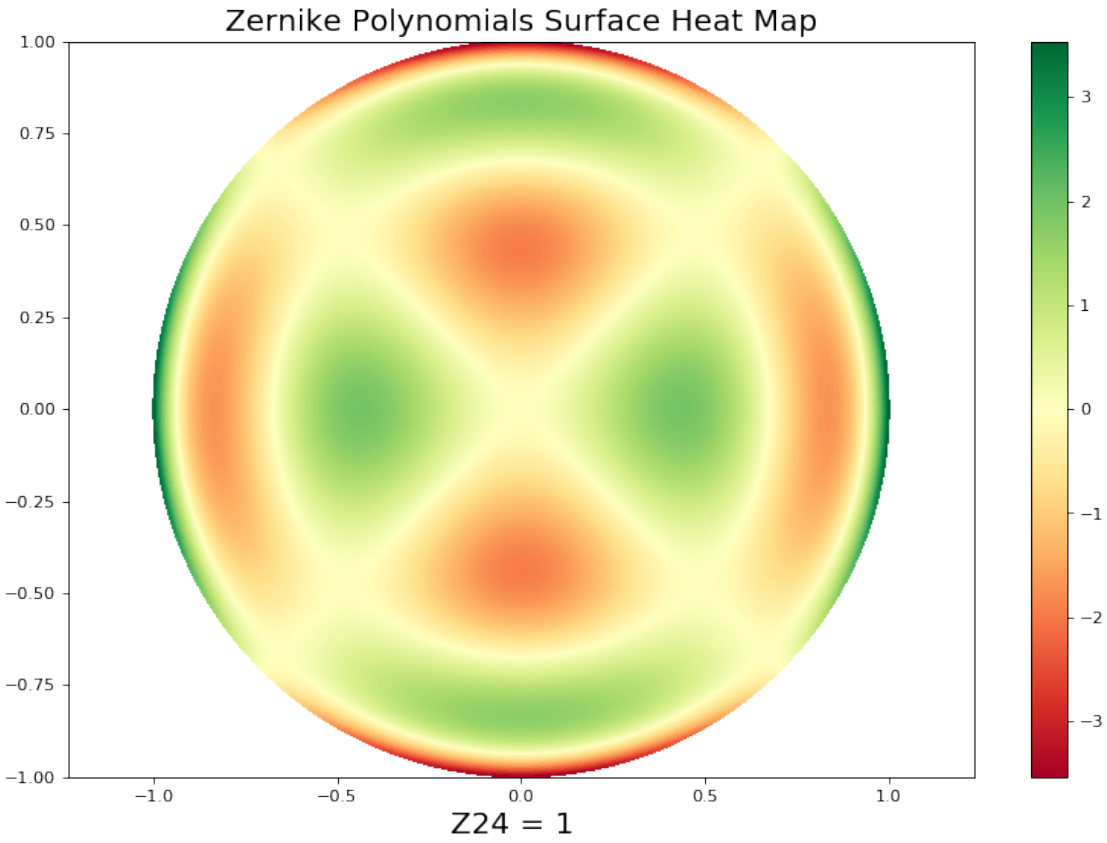
Z22 = 1 Z60 Secondary Spherical



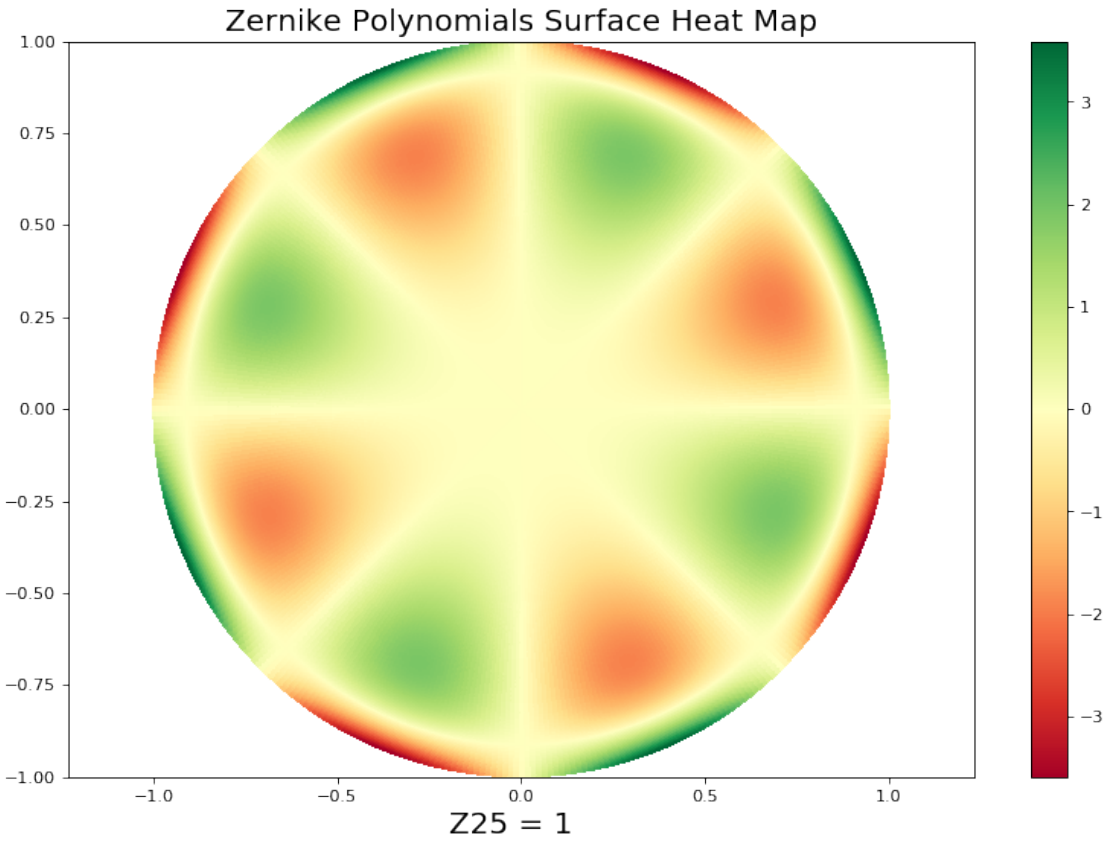
Z23 = 1 Z62 Tertiary Astigmatism at 45



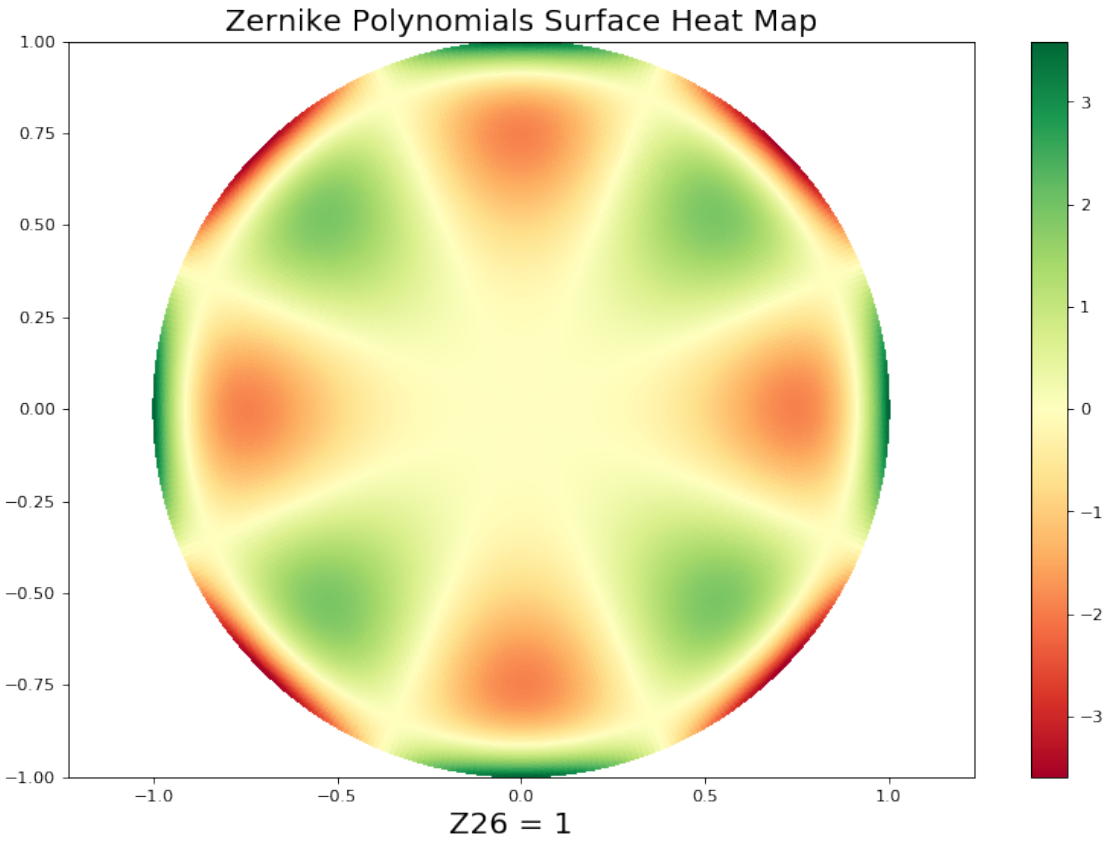
Z24 = 1 Z62 Tertiary Astigmatism at 0



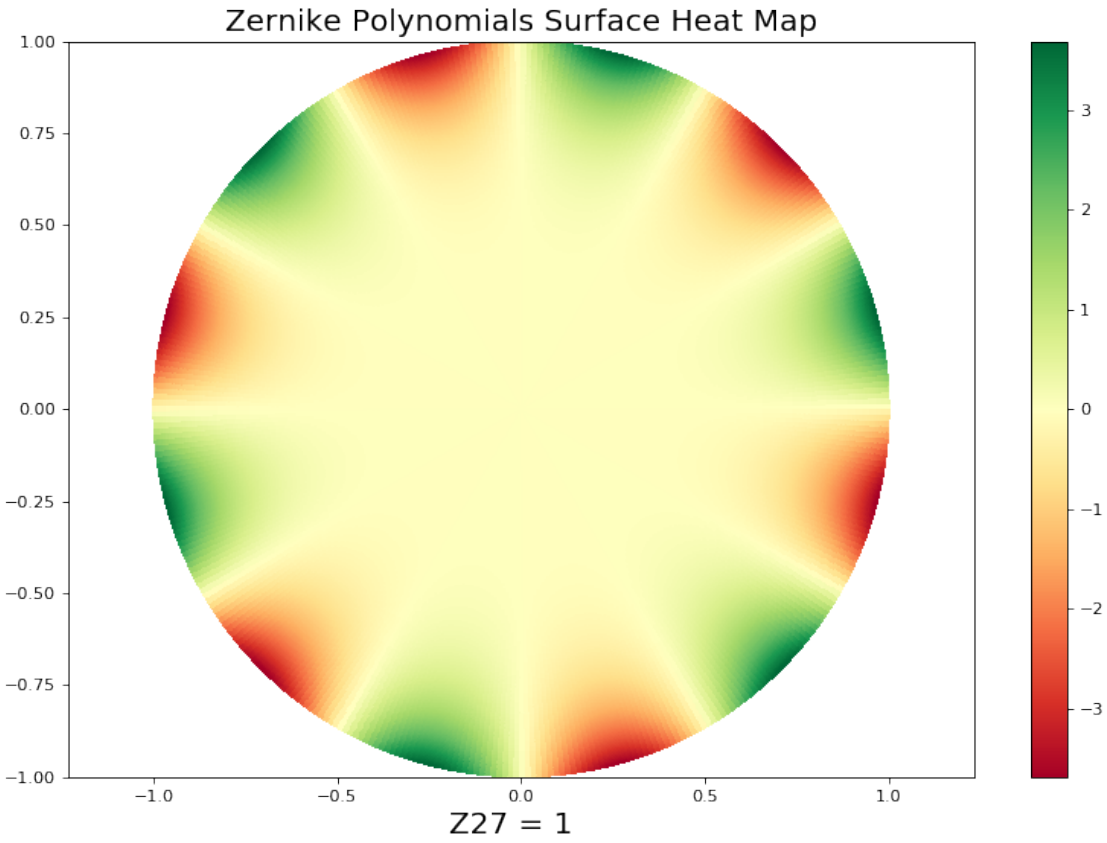

```
Z25 =  1 Z64 Secondary x Trefoil
```



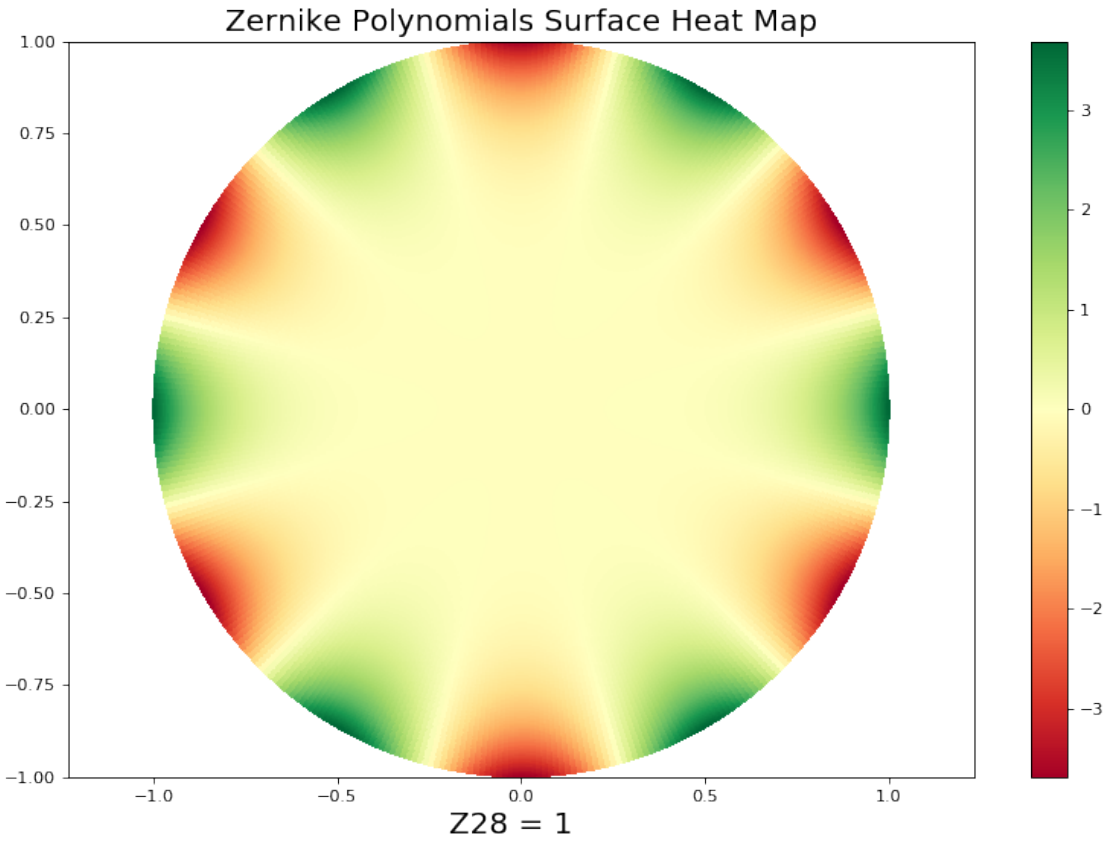
Z26 = 1 Z64 Secondary y Trefoil



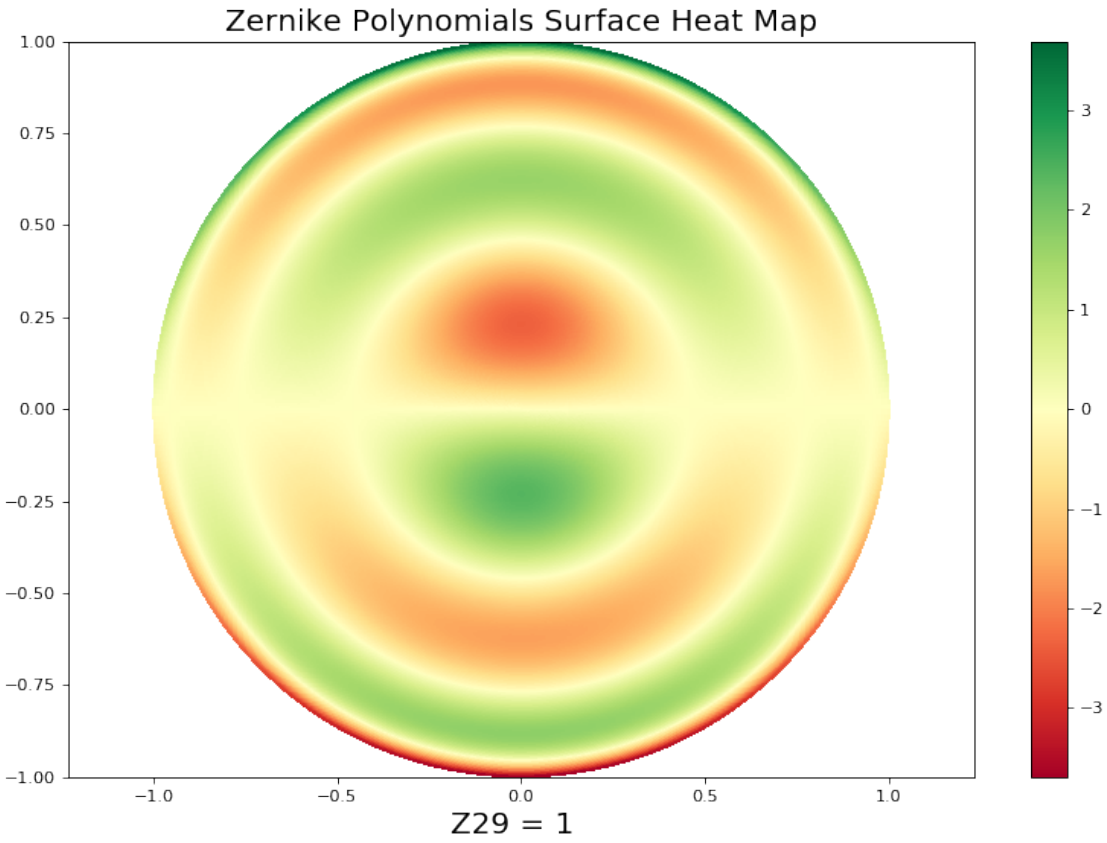
Z27 = 1 Z66 Hexafoil Y



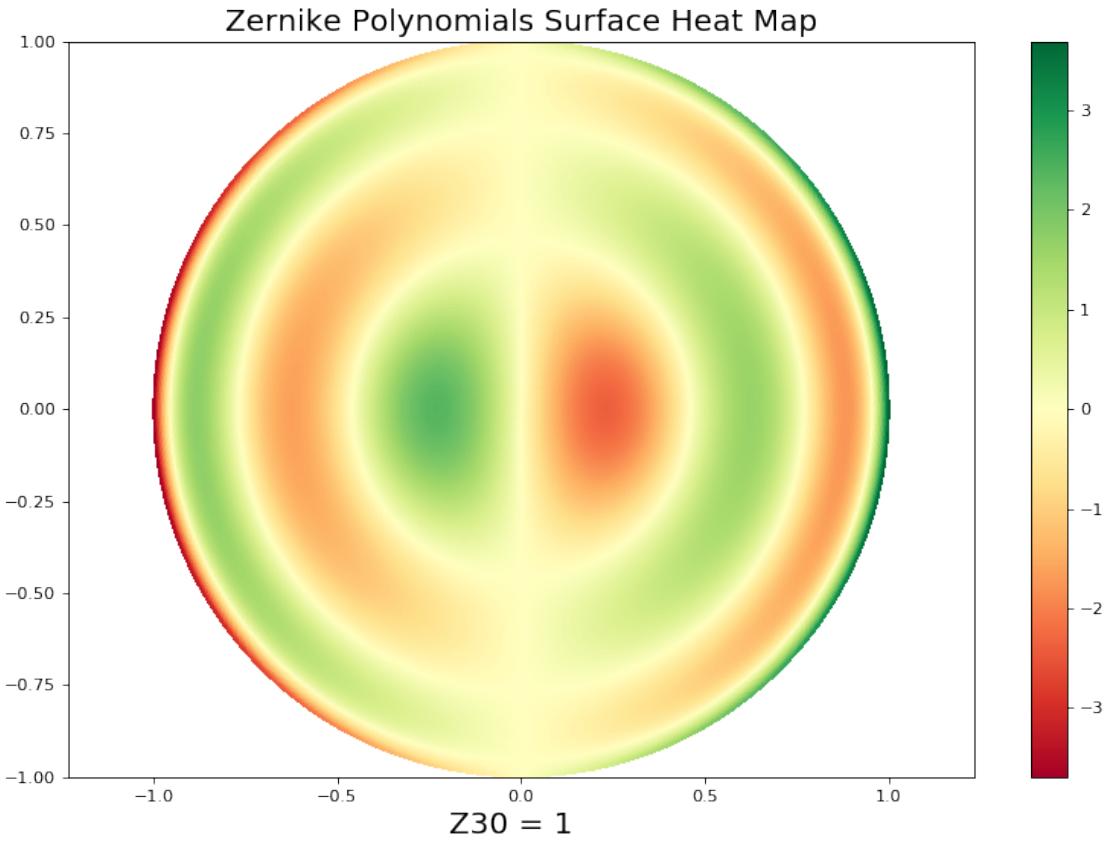
Z28 = 1 Z66 Hexafoil X



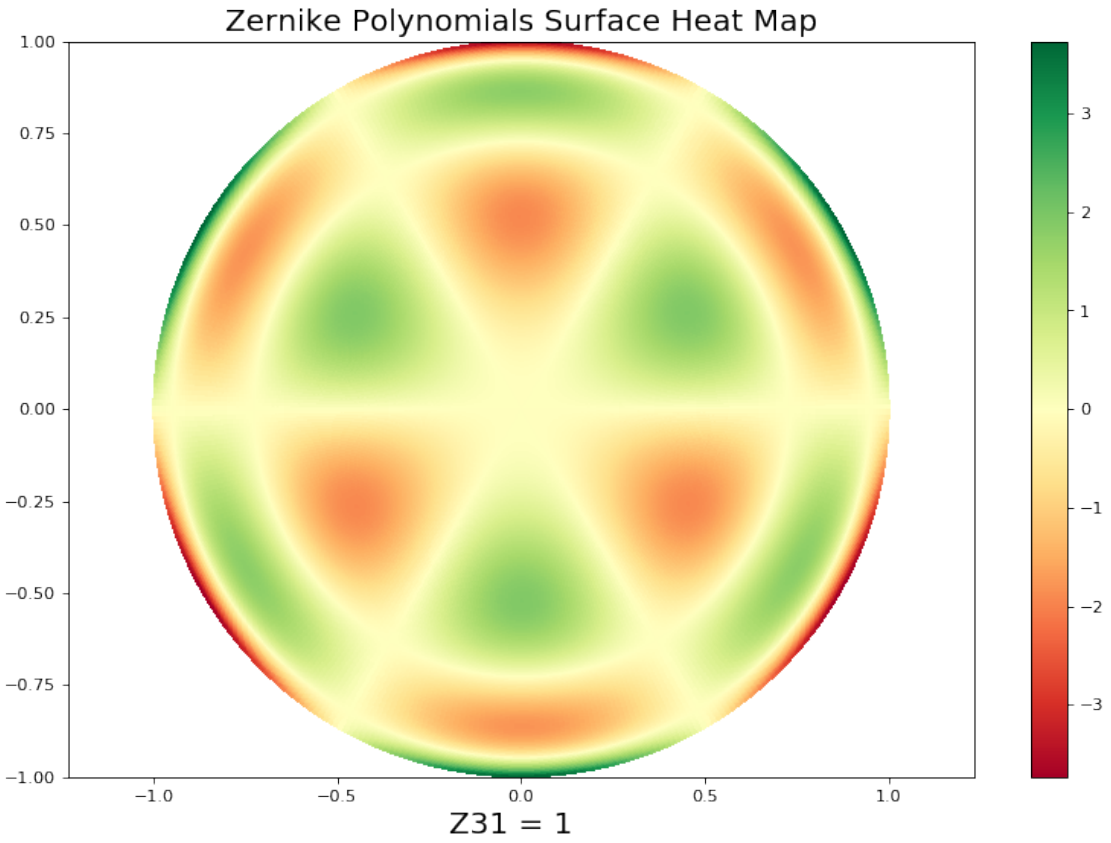
Z29 = 1 Z71 Tertiary y Coma



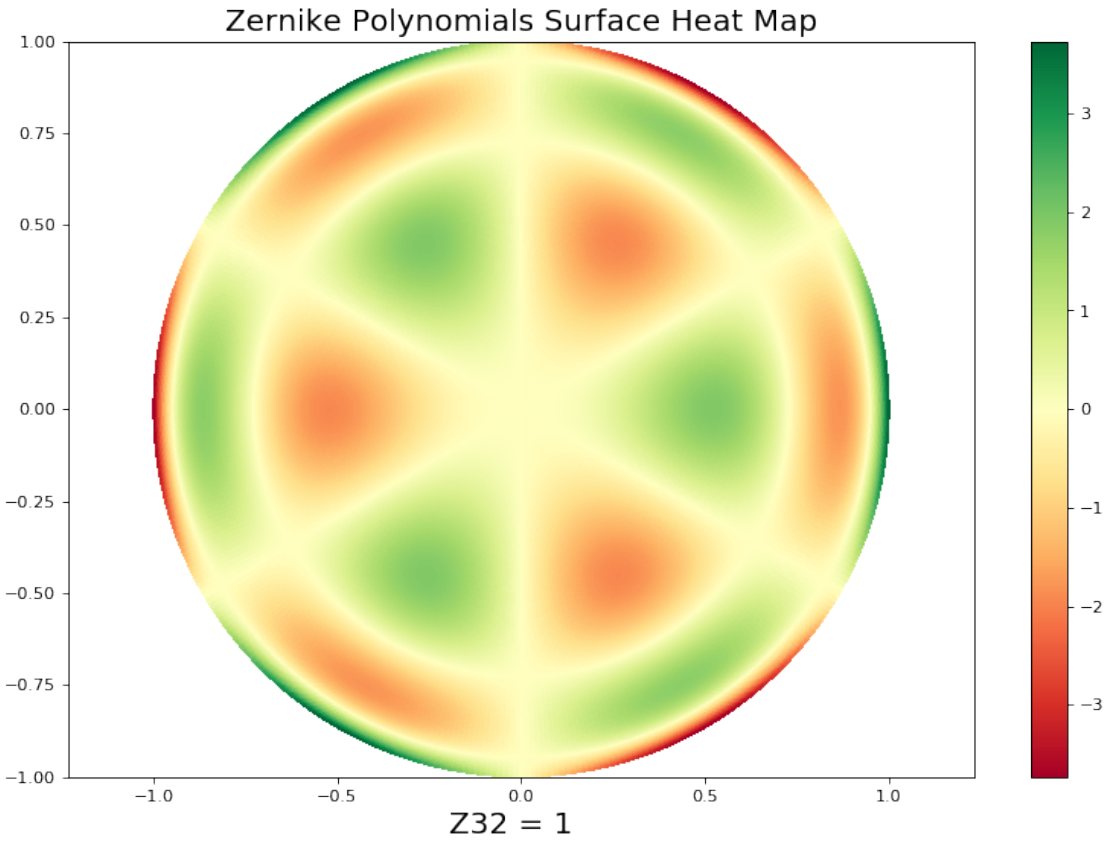
Z30 = 1 Z71 Tertiary x Coma



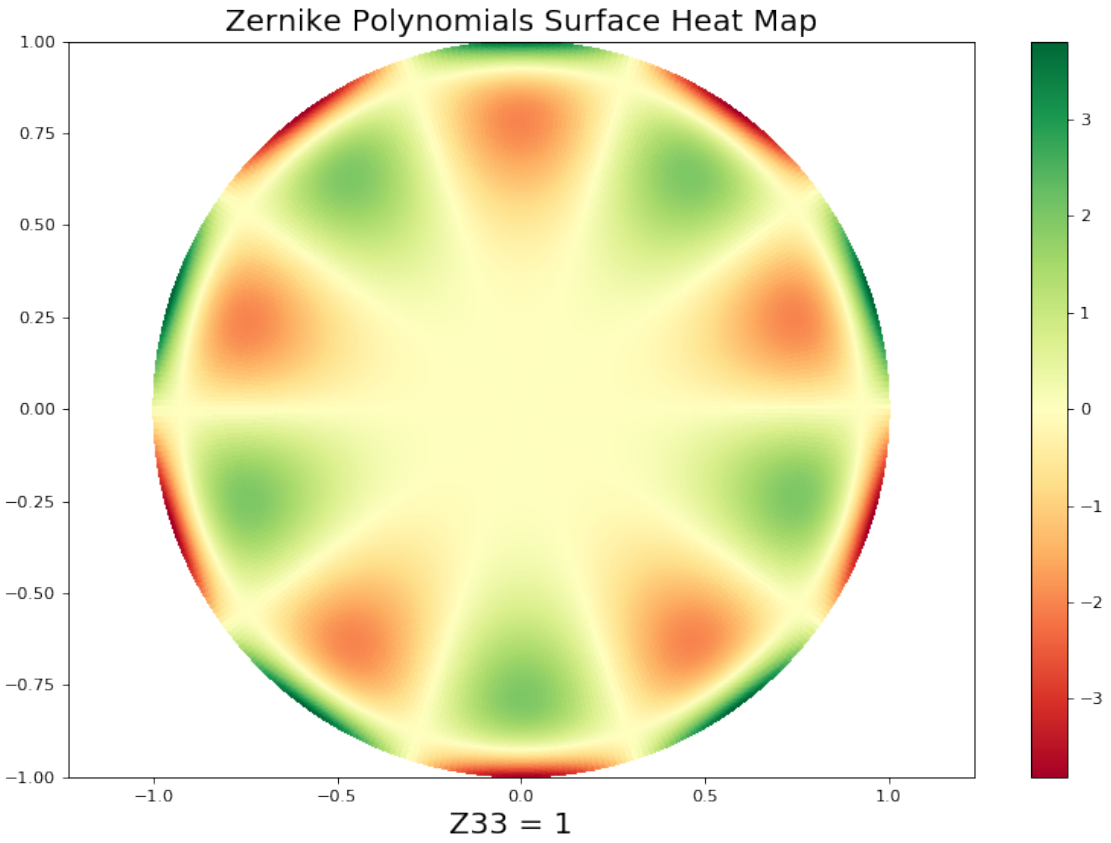
Z31 = 1 Z73 Tertiary y Trefoil



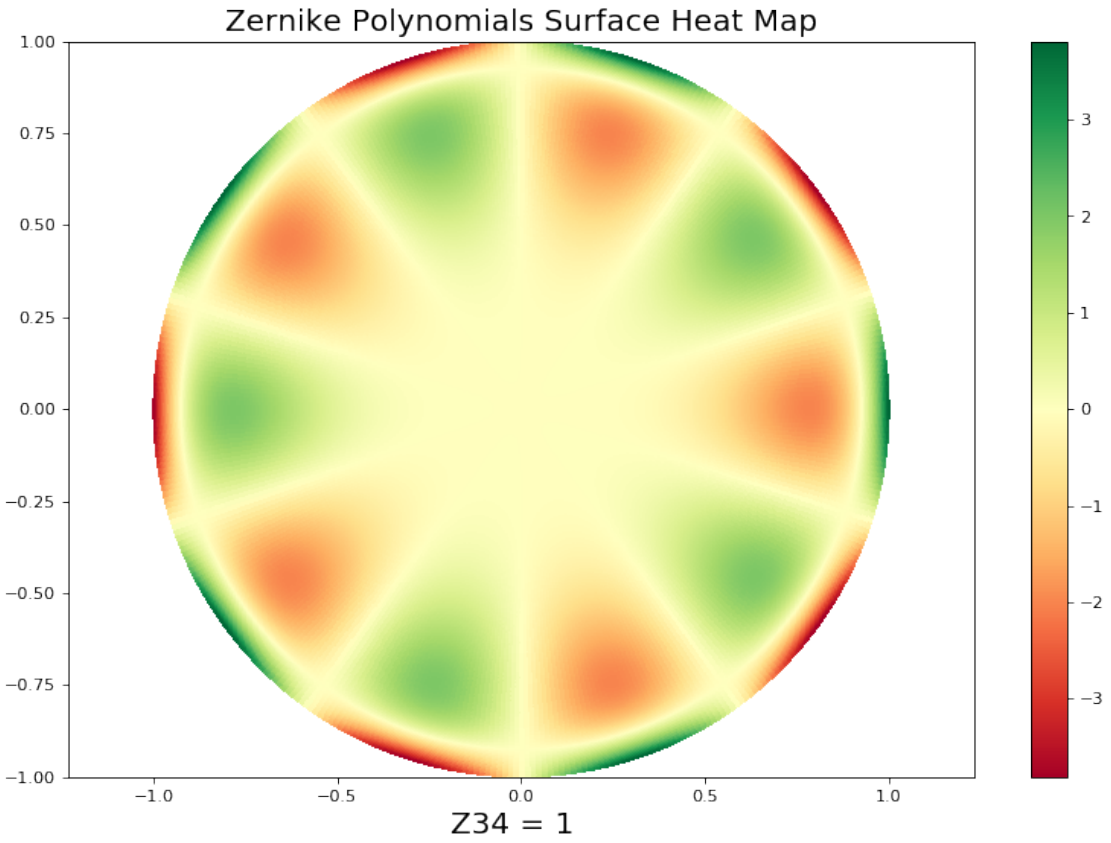
Z32 = 1 Z73 Tertiary x Trefoil



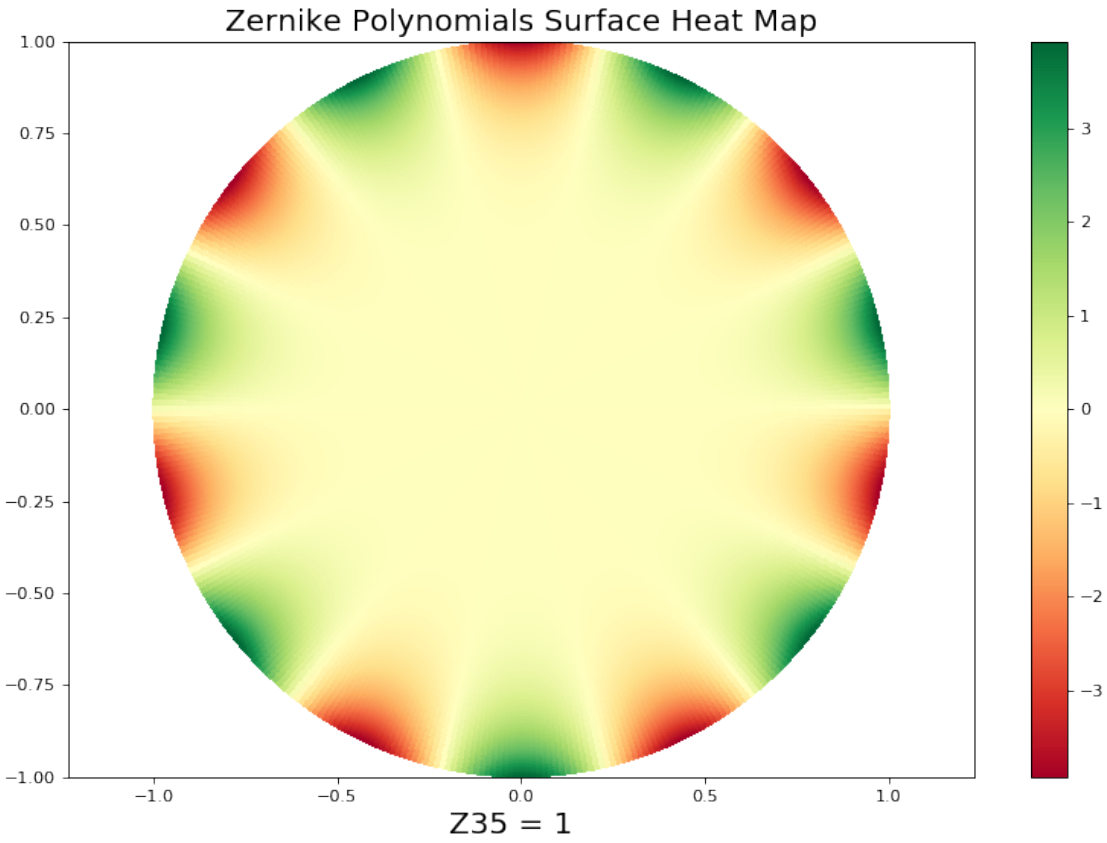

```
Z33 =  1 Z75 Secondary Pentafoil Y
```



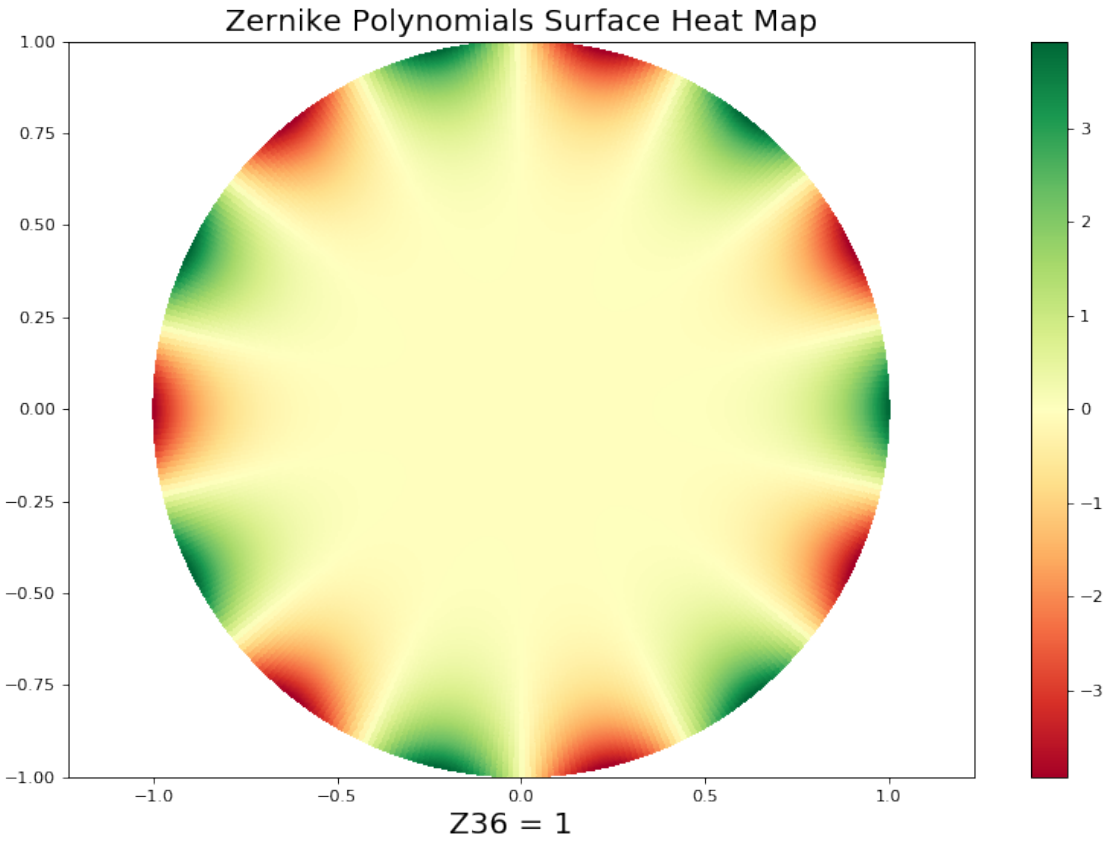
Z34 = 1 Z75 Secondary Pentafoil X



Z35 = 1 Z77 Heptafoil Y



Z36 = 1 Z77 Heptafoil X

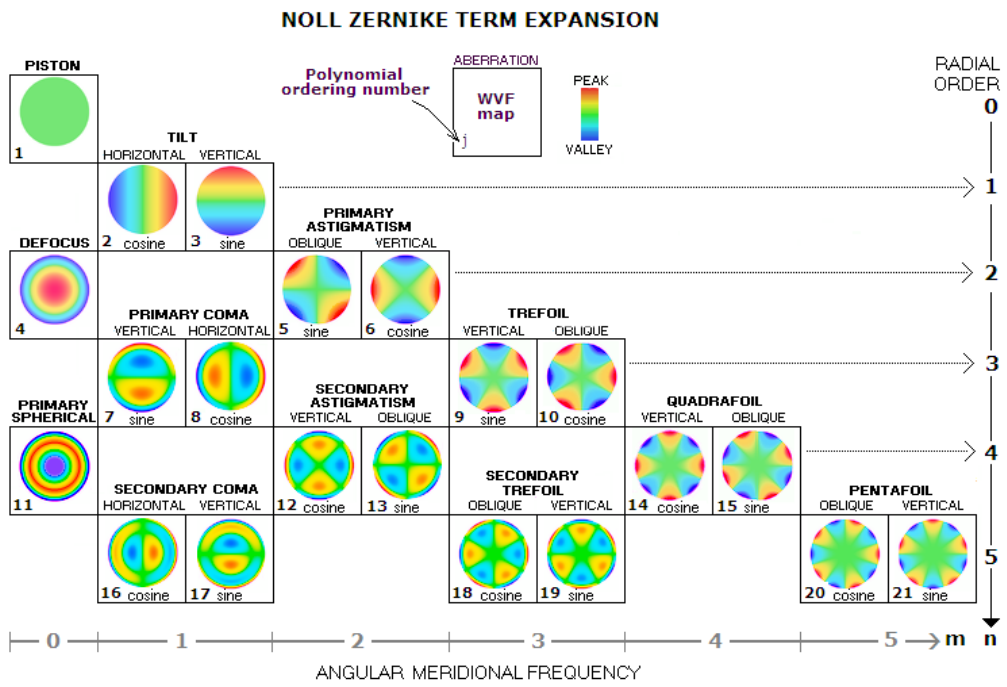


1.1 Make sure opticspy order matches NOLL order

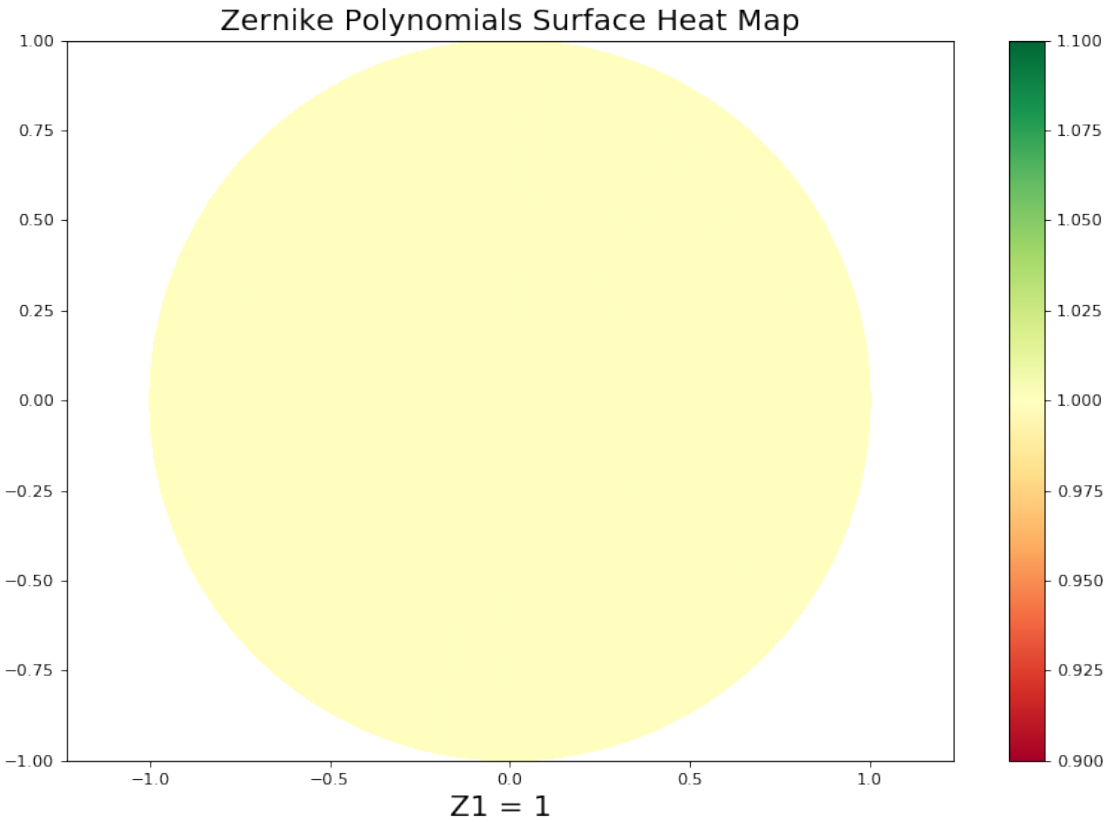
```
In [4]: # now convert to ANSI ordering
        ansiZs = noll2ansi(zs)

In [5]: # plot the new ordering
        for i, z in enumerate(ansiZs):
            print i; z.zernikemap()
```

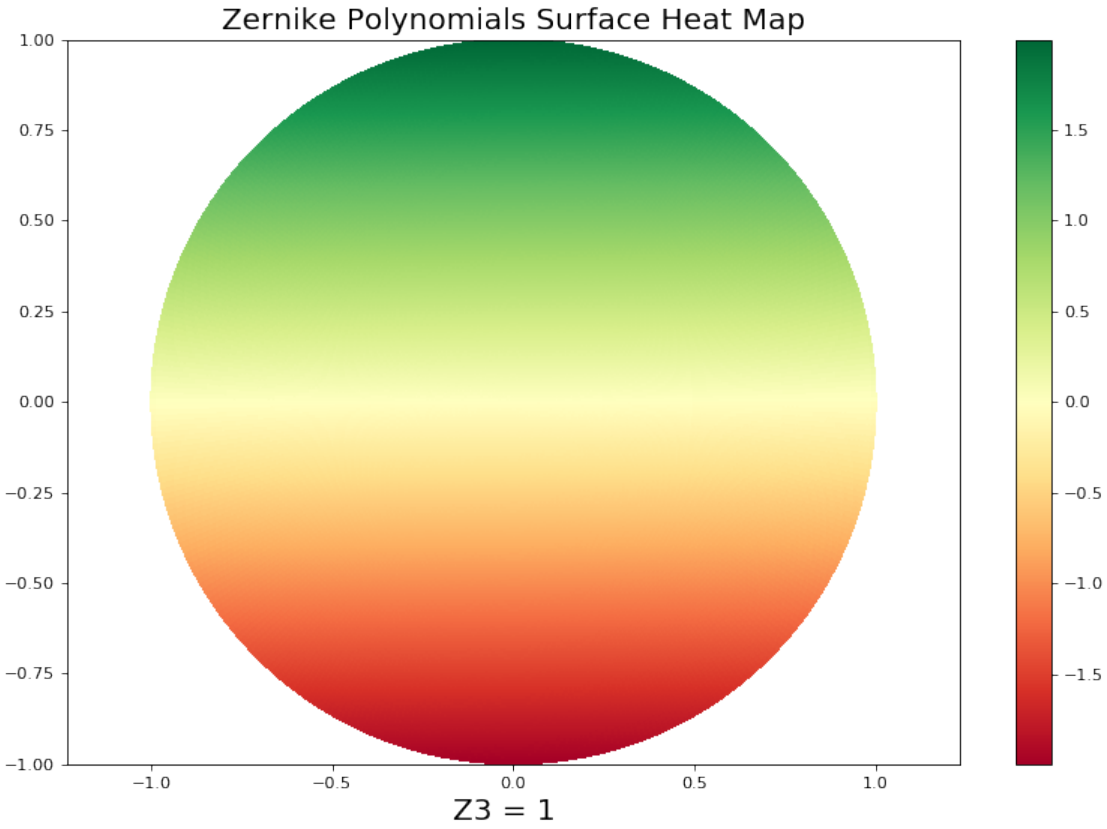
```
0
Z1 =  1 Z00 Piston or Bias
```


NOLL ZERNIKE TERM EXPANSION
PISTON
1
Polynomial ordering number
ABERRATION
WVF map
j
PEAK
VALLEY
RADIAL ORDER
0
TILT
HORIZONTAL
VERTICAL
2 cosine
3 sine
1
PRIMARY ASTIGMATISM
OBLIQUE
VERTICAL
DEFOCUS
4
5 sine
6 cosine
2
PRIMARY COMA
VERTICAL
HORIZONTAL
TREFOIL
VERTICAL
OBLIQUE
7 sine
8 cosine
9 sine
10 cosine
3
SECONDARY ASTIGMATISM
VERTICAL
OBLIQUE
QUADRAFOIL
VERTICAL
OBLIQUE
PRIMARY SPHERICAL
11
12 cosine
13 sine
14 cosine
15 sine
4
SECONDARY COMA
HORIZONTAL
VERTICAL
SECONDARY TREFOIL
OBLIQUE
VERTICAL
PENTAFOIL
OBLIQUE
VERTICAL
16 cosine
17 sine
18 cosine
19 sine
20 cosine
21 sine
5
0
1
2
3
4
5
m
n
ANGULAR MERIDIONAL FREQUENCY

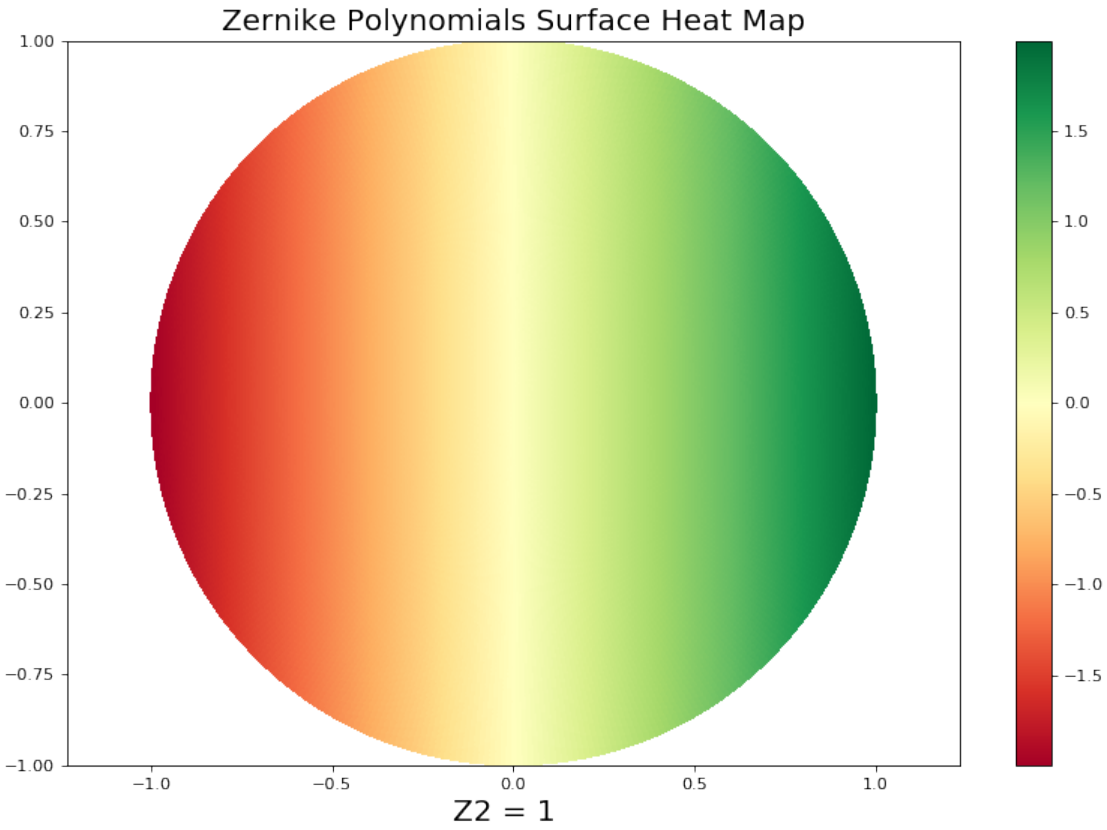
noll


Zernike Polynomials Surface Heat Map
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.0
−0.5
0.0
0.5
1.0
1.100
1.075
1.050
1.025
1.000
0.975
0.950
0.925
0.900
Z1 = 1

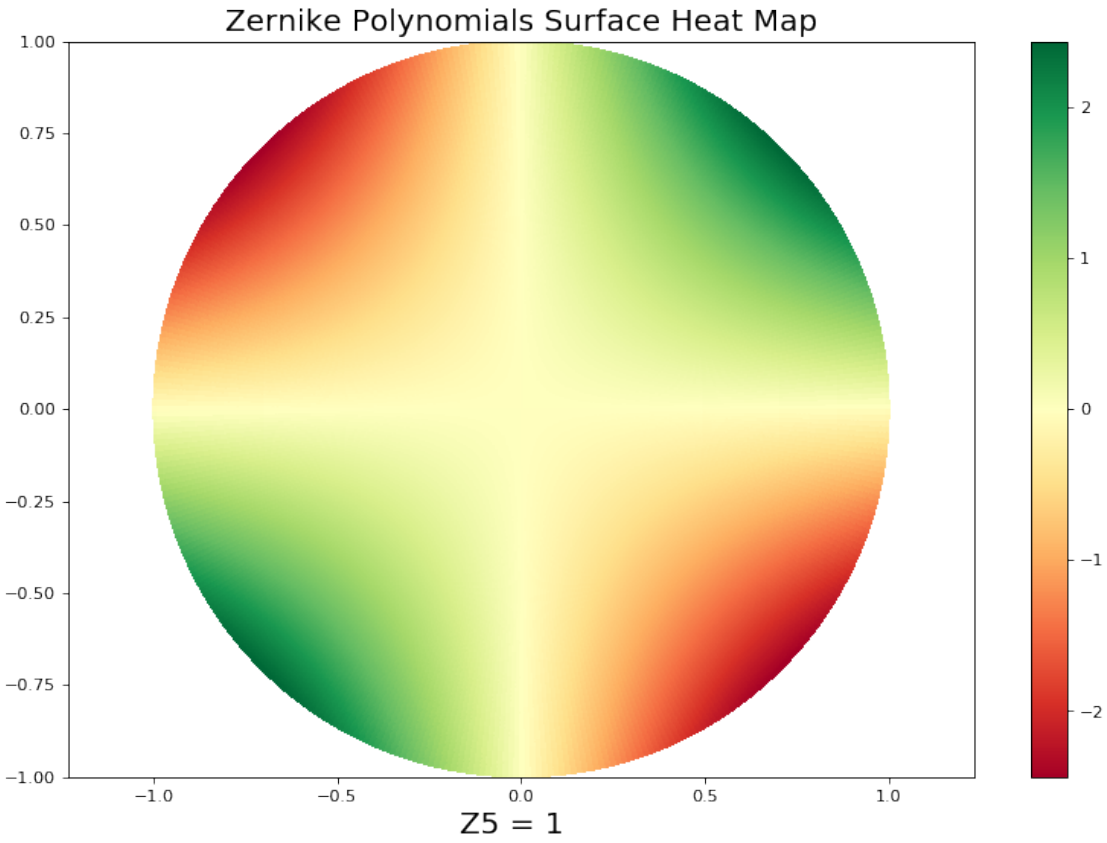
1
Z3 = 1 Z11 y Tilt



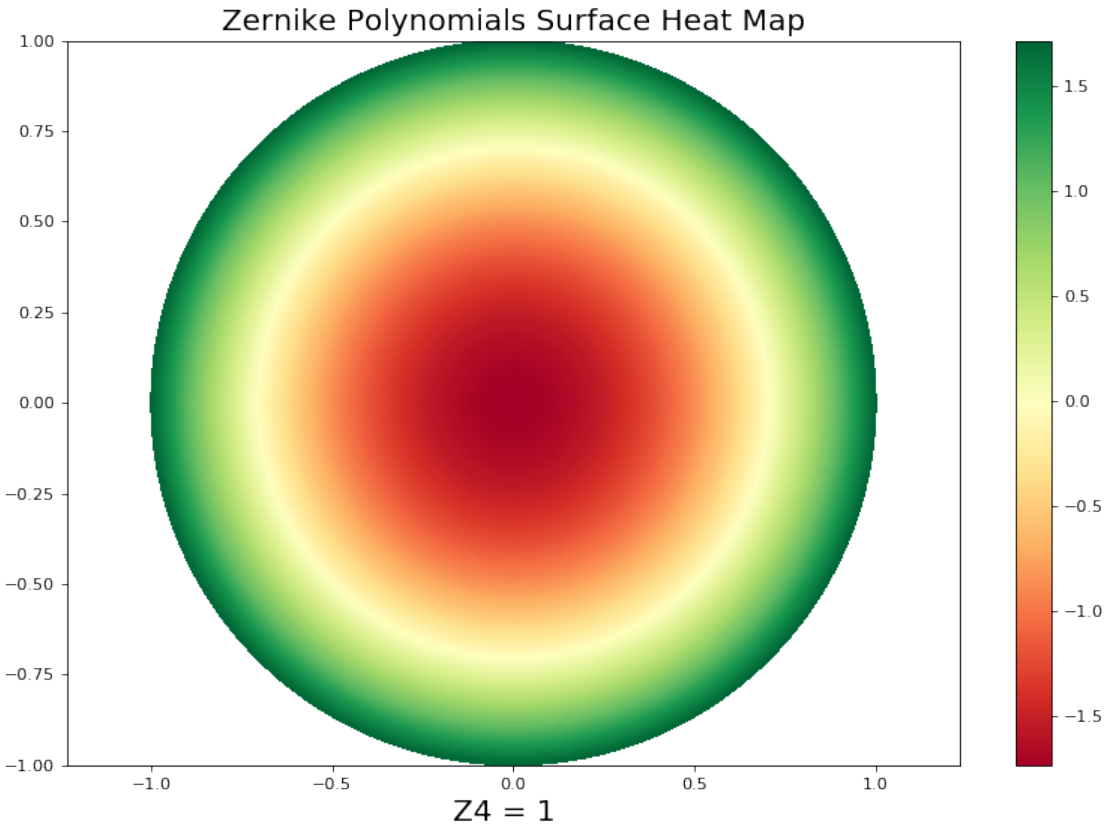
2
Z2 = 1 Z11 x Tilt



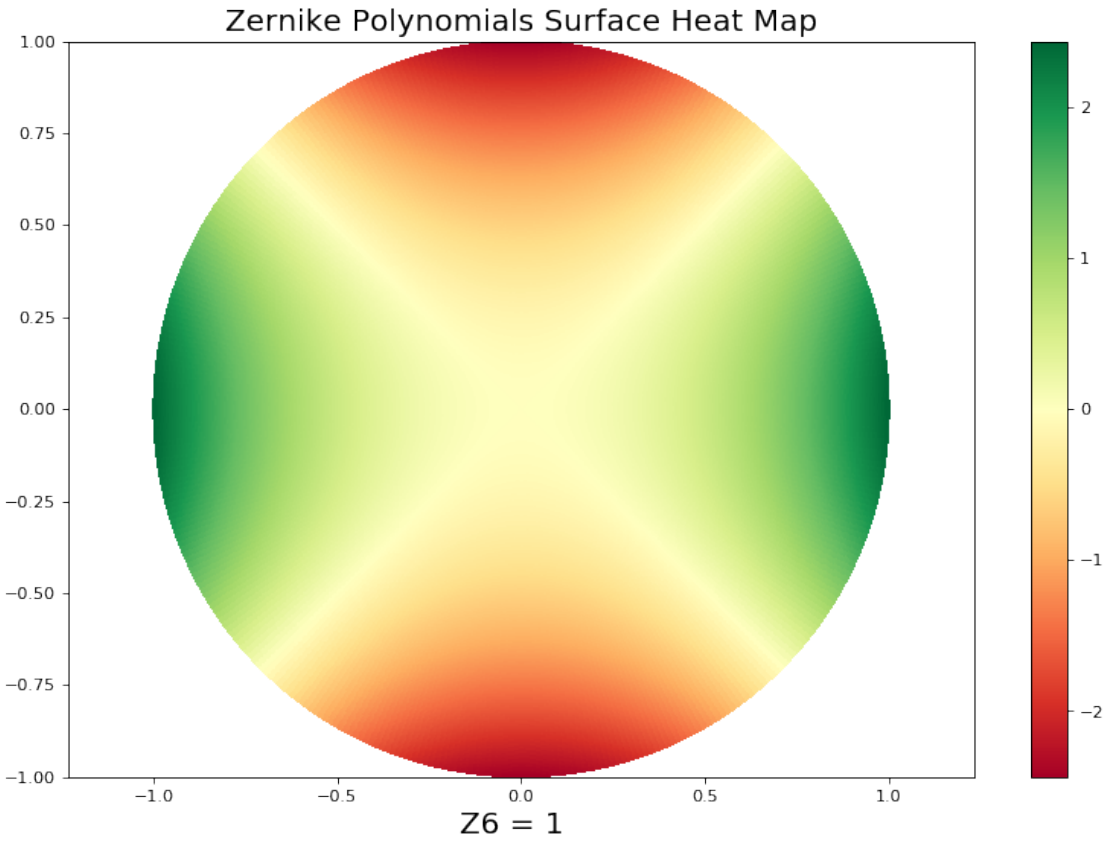
3
Z5 = 1 Z22 Primary Astigmatism at 45



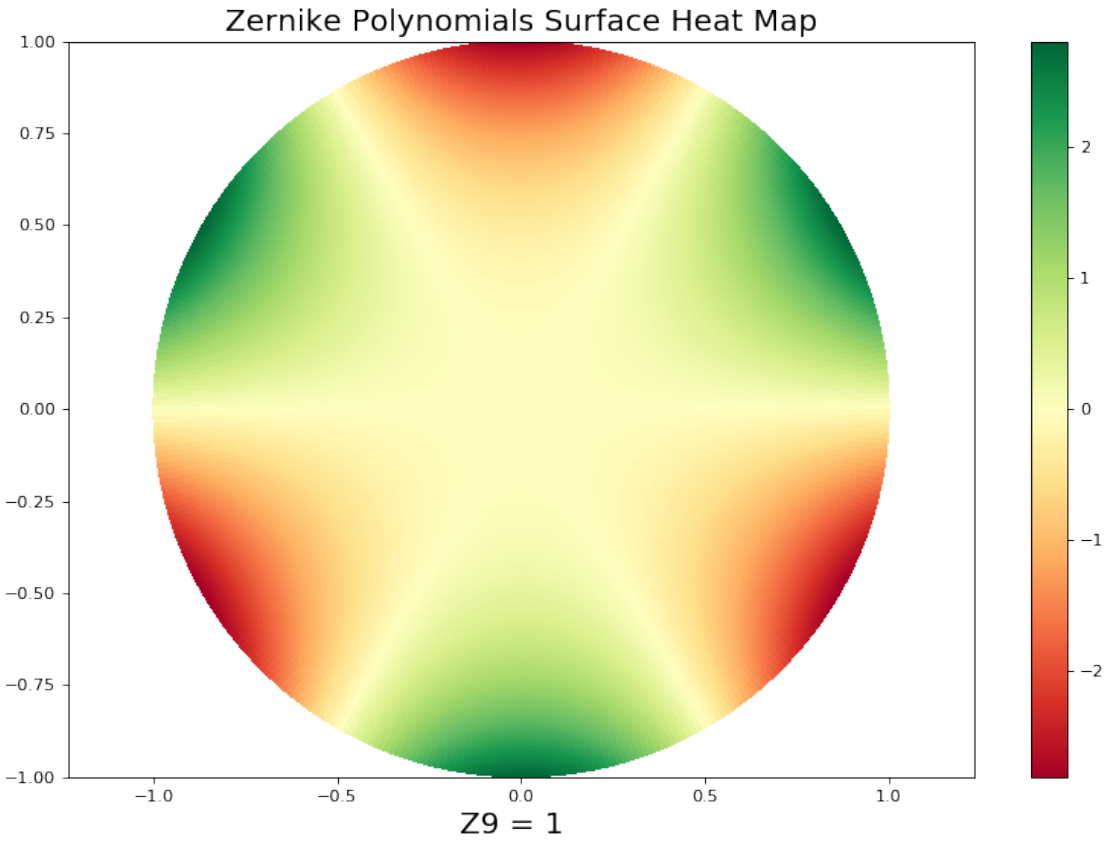

```
4
Z4 =  1 Z20 Defocus
```



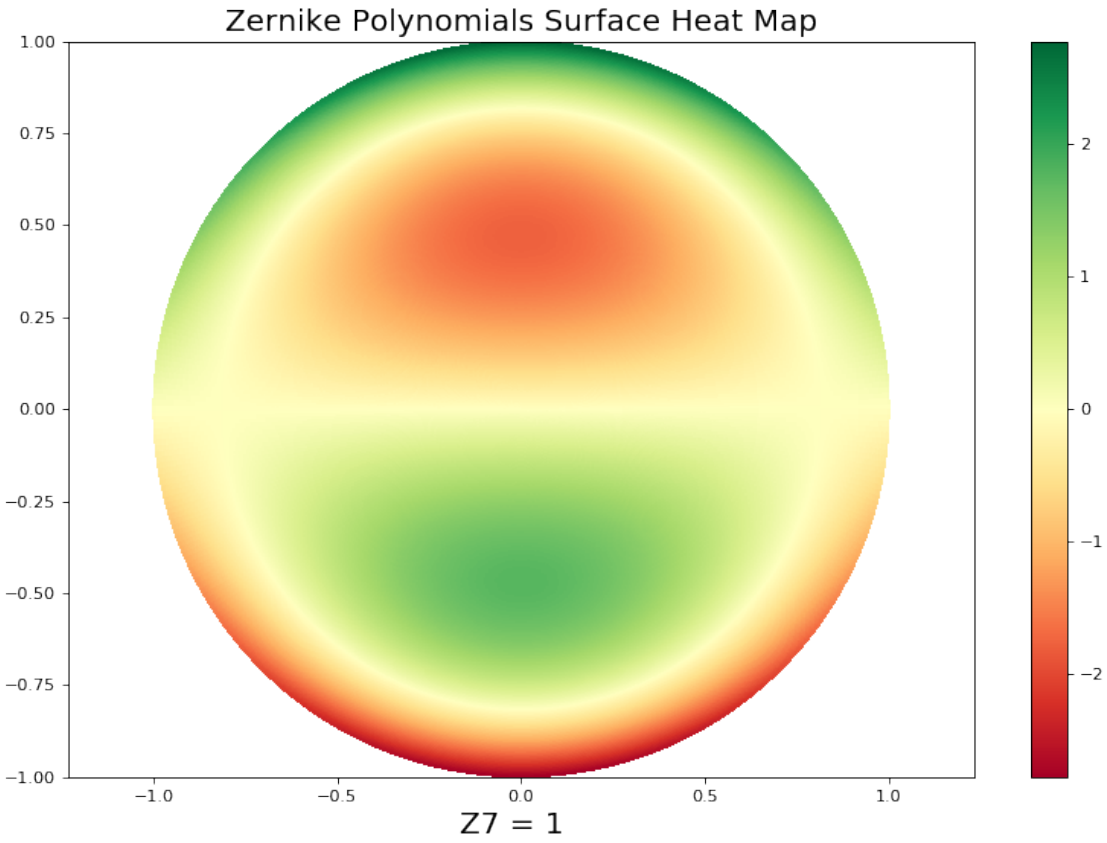

```
5
Z6 =  1 Z22 Primary Astigmatism at 0
```



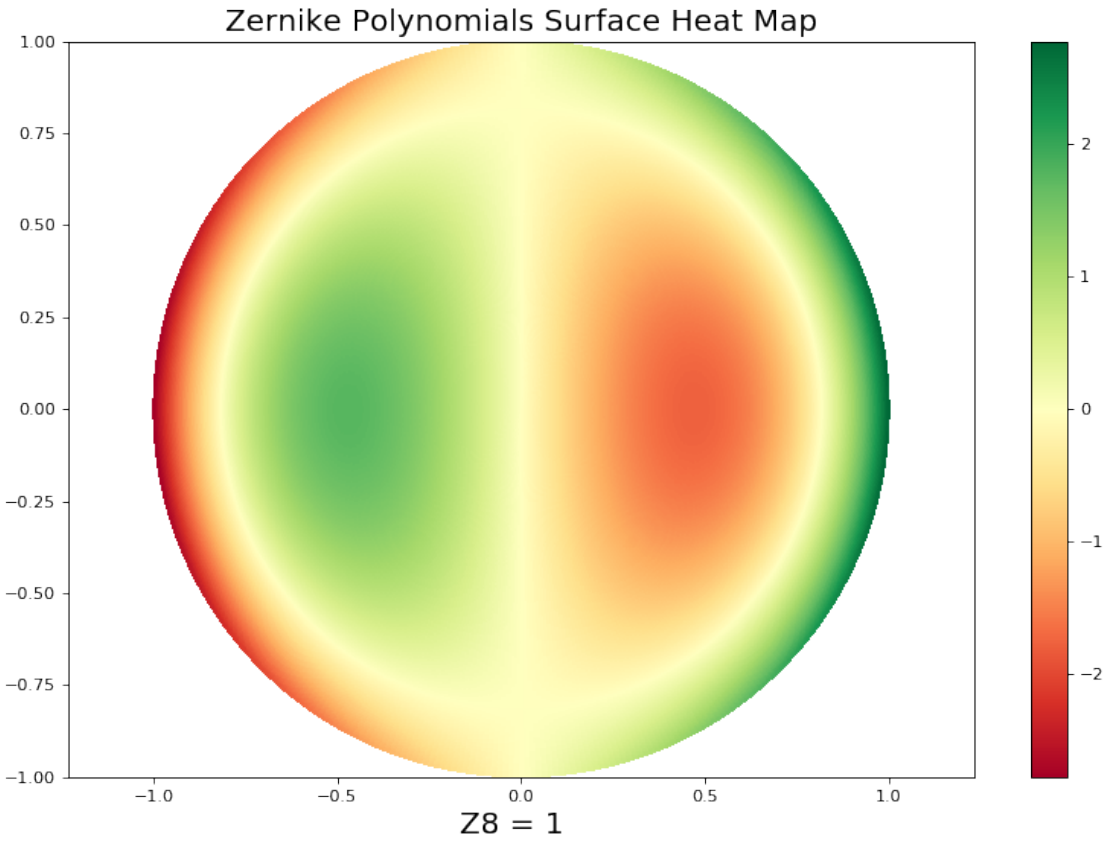
6
Z9 = 1 Z33 y Trefoil



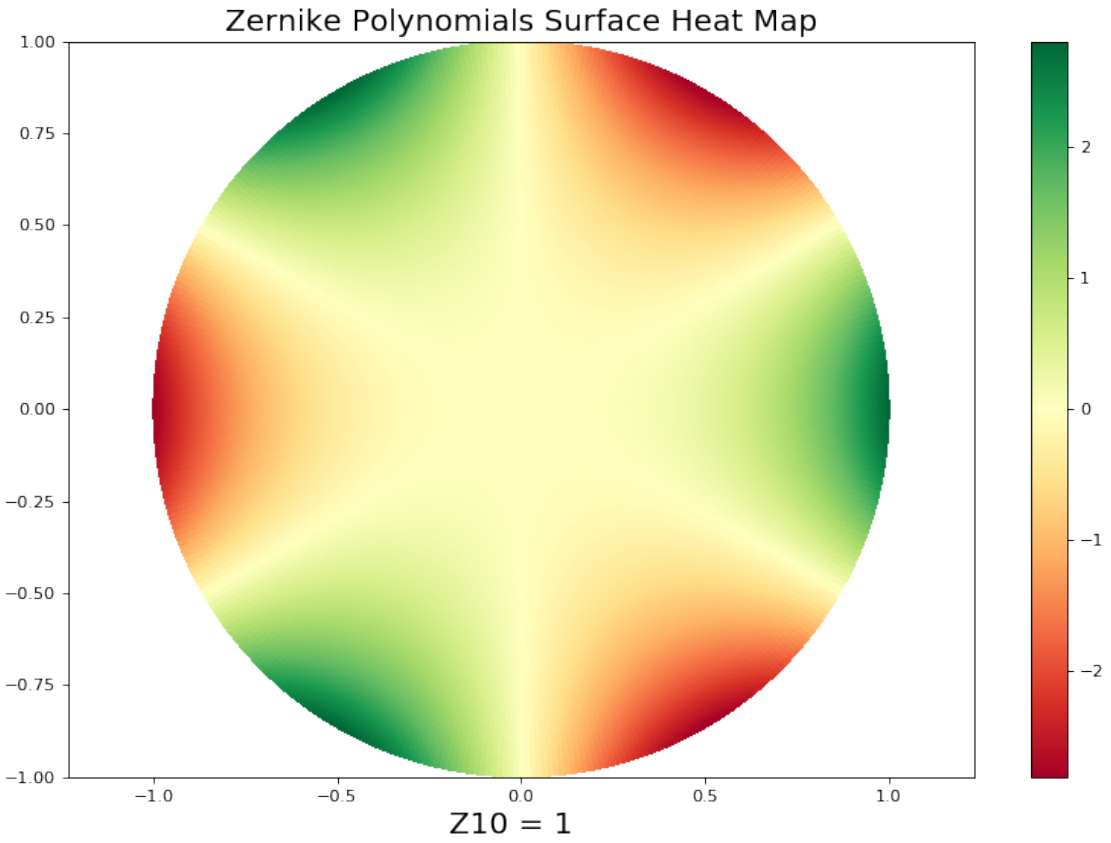

```
7
Z7 =  1 Z31 Primary y Coma
```



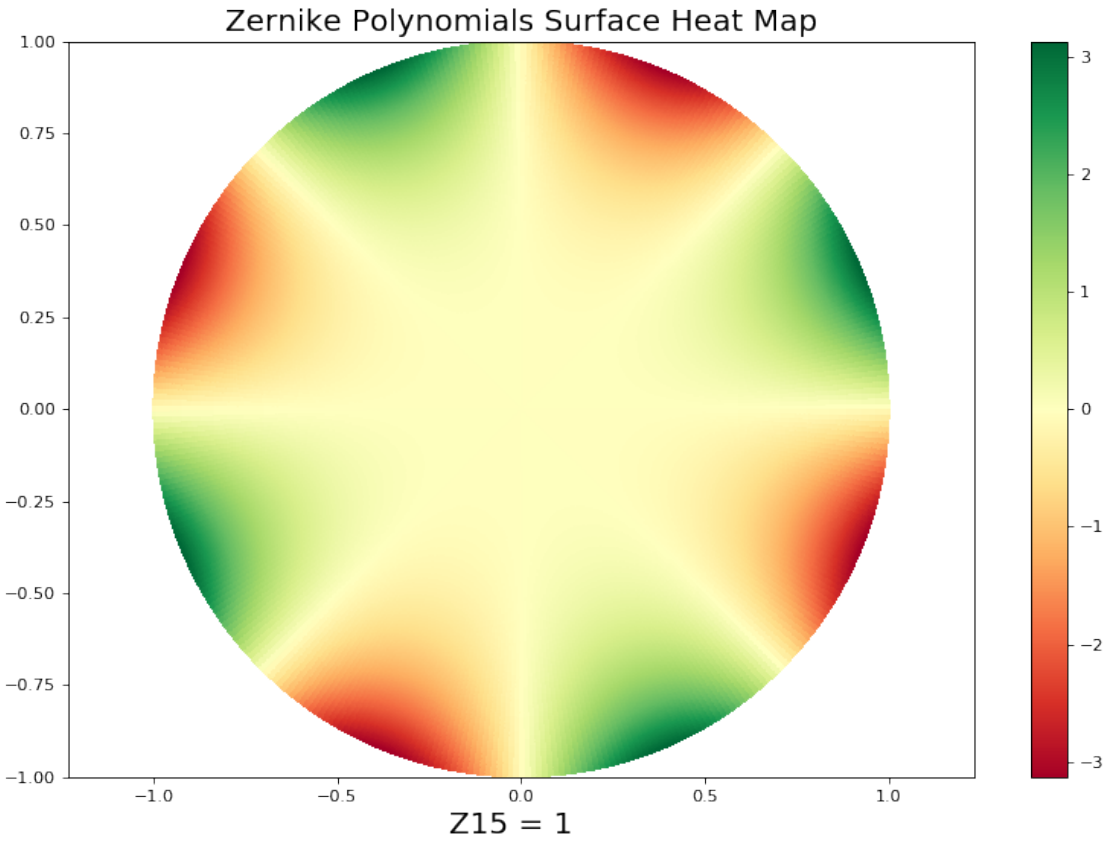

```
8
Z8 =  1 Z31 Primary x Coma
```



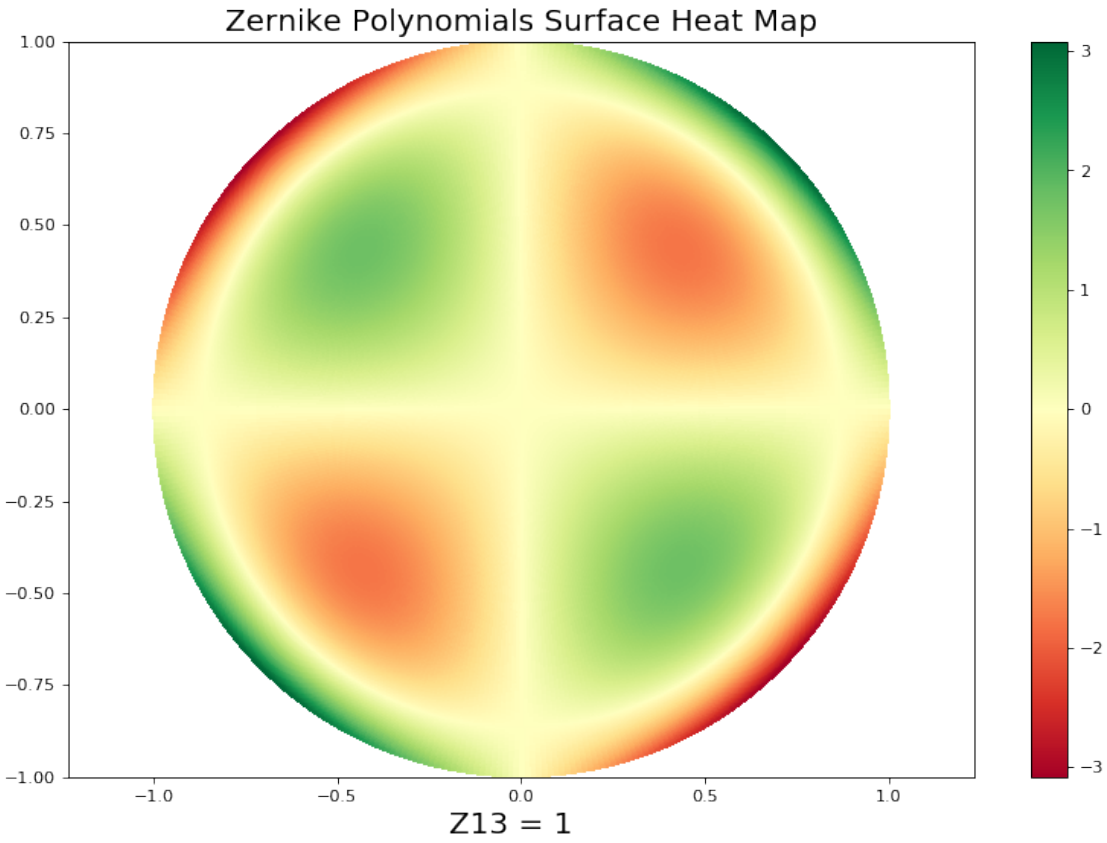
9
Z10 = 1 Z33 x Trefoil



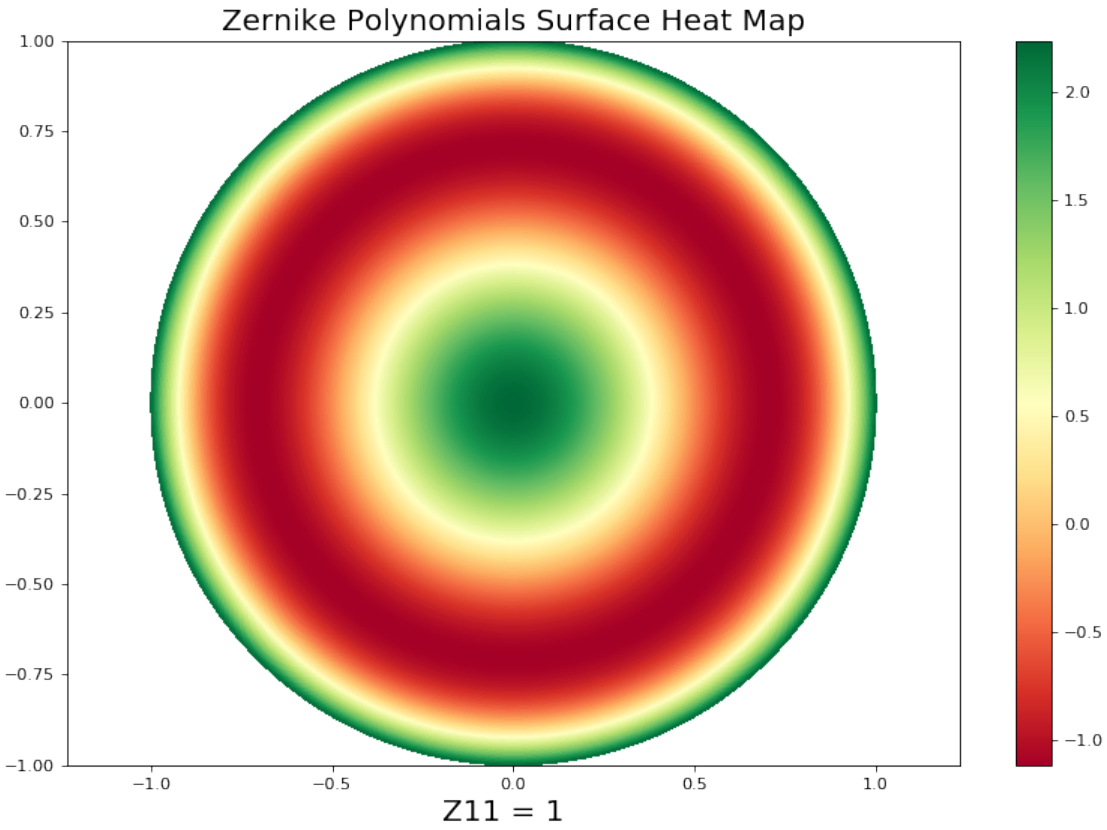
10
Z15 = 1 Z44 y Tetrafoil



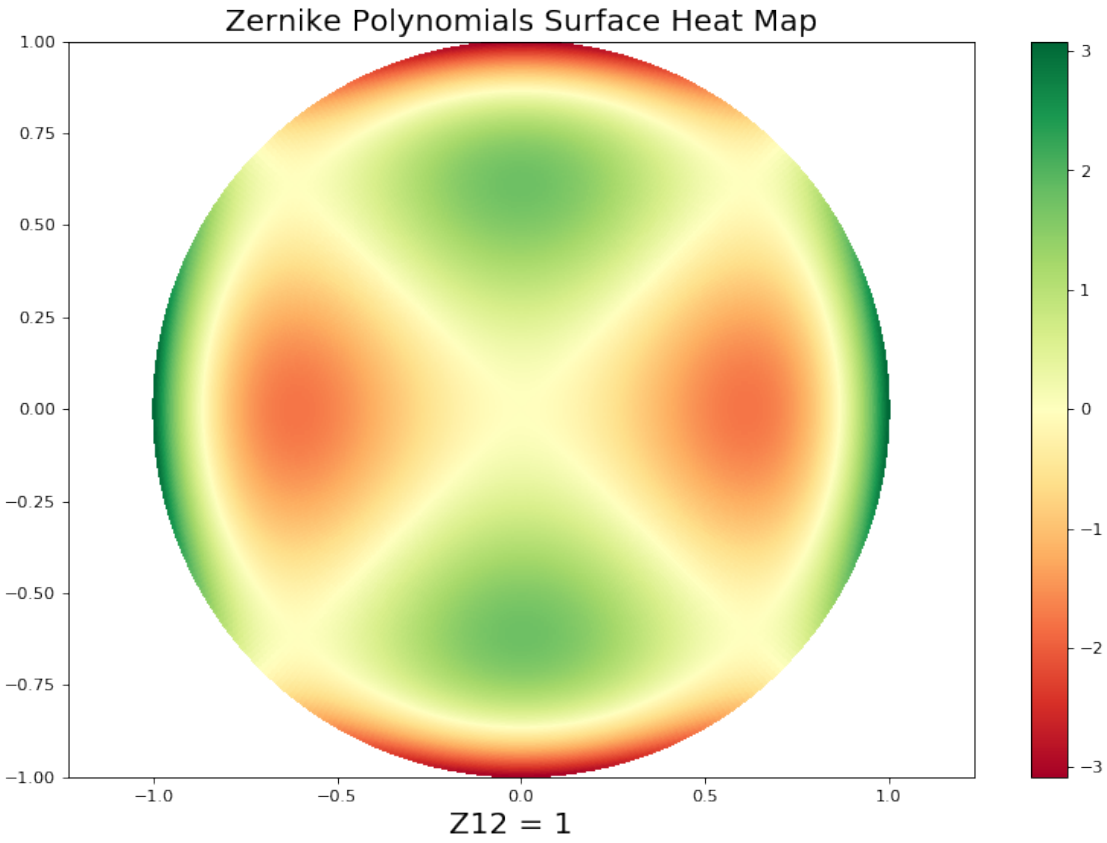

```
11
Z13 =  1 Z42 Secondary Astigmatism at 45
```



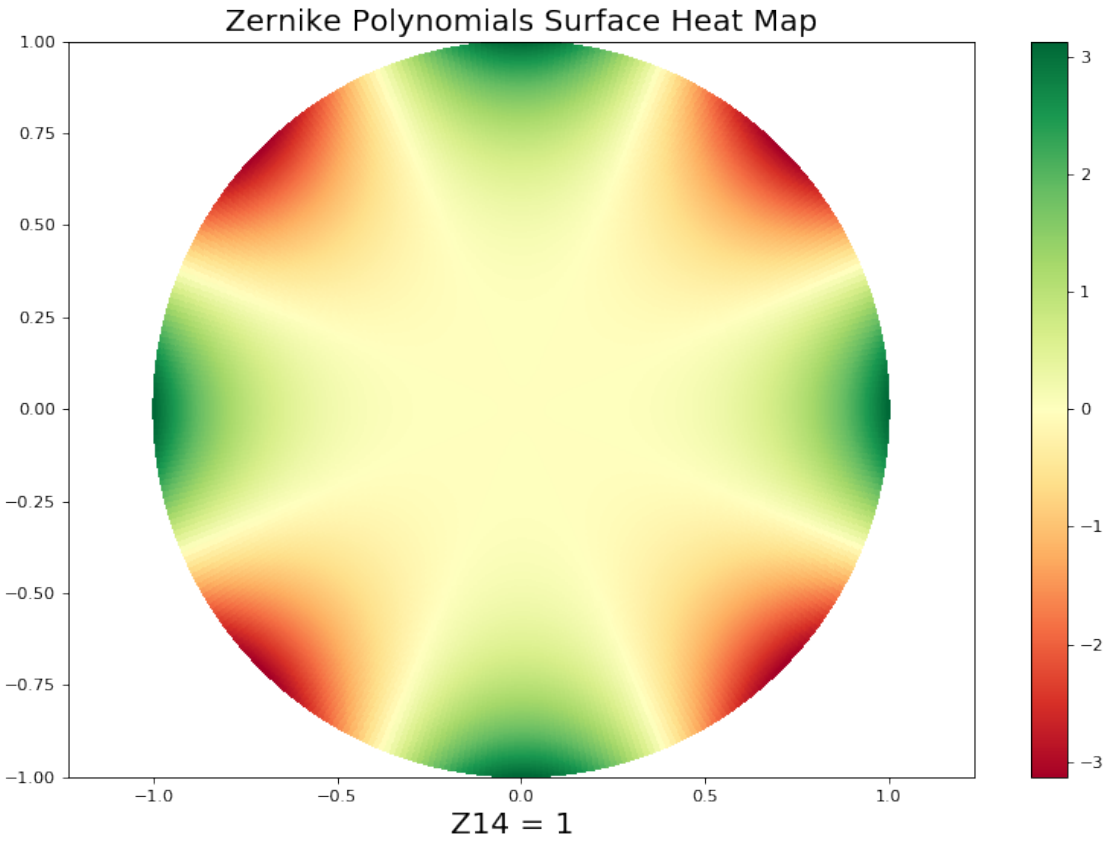

```
12
Z11 =  1 Z40 Primary Spherical
```



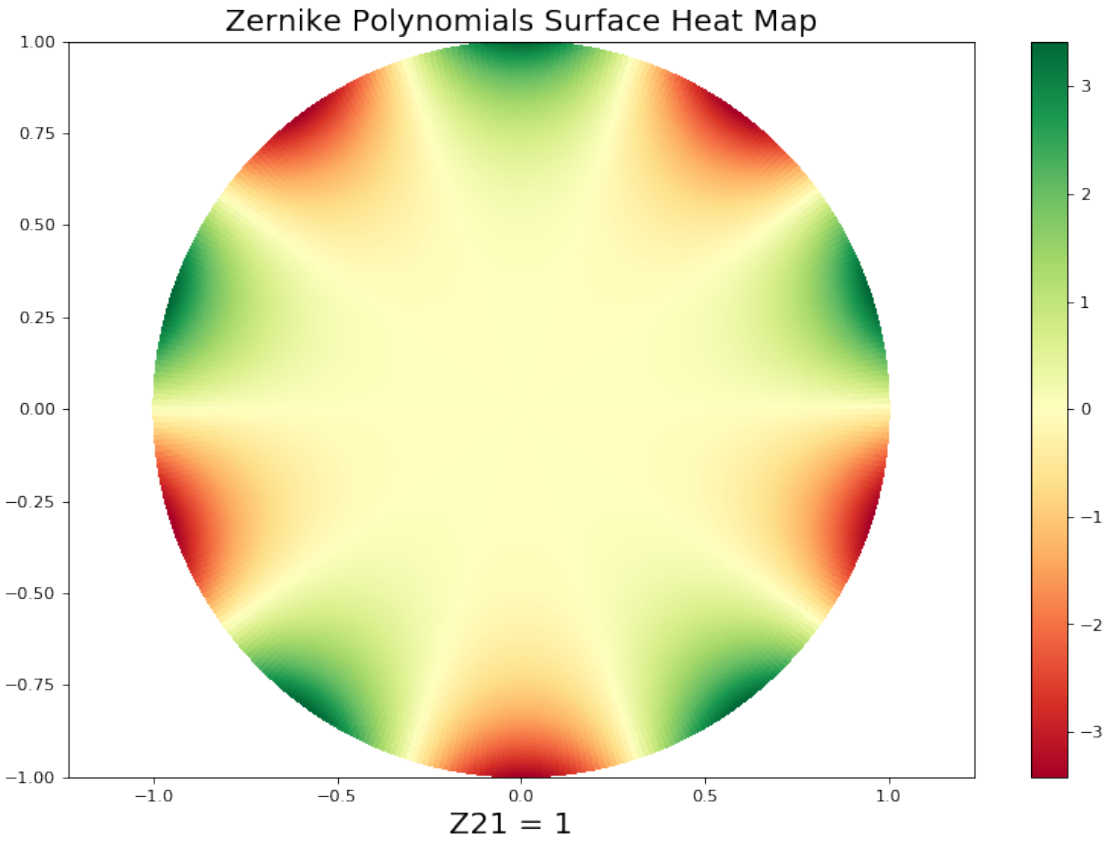
13
Z12 = 1 Z42 Secondary Astigmatism at 0



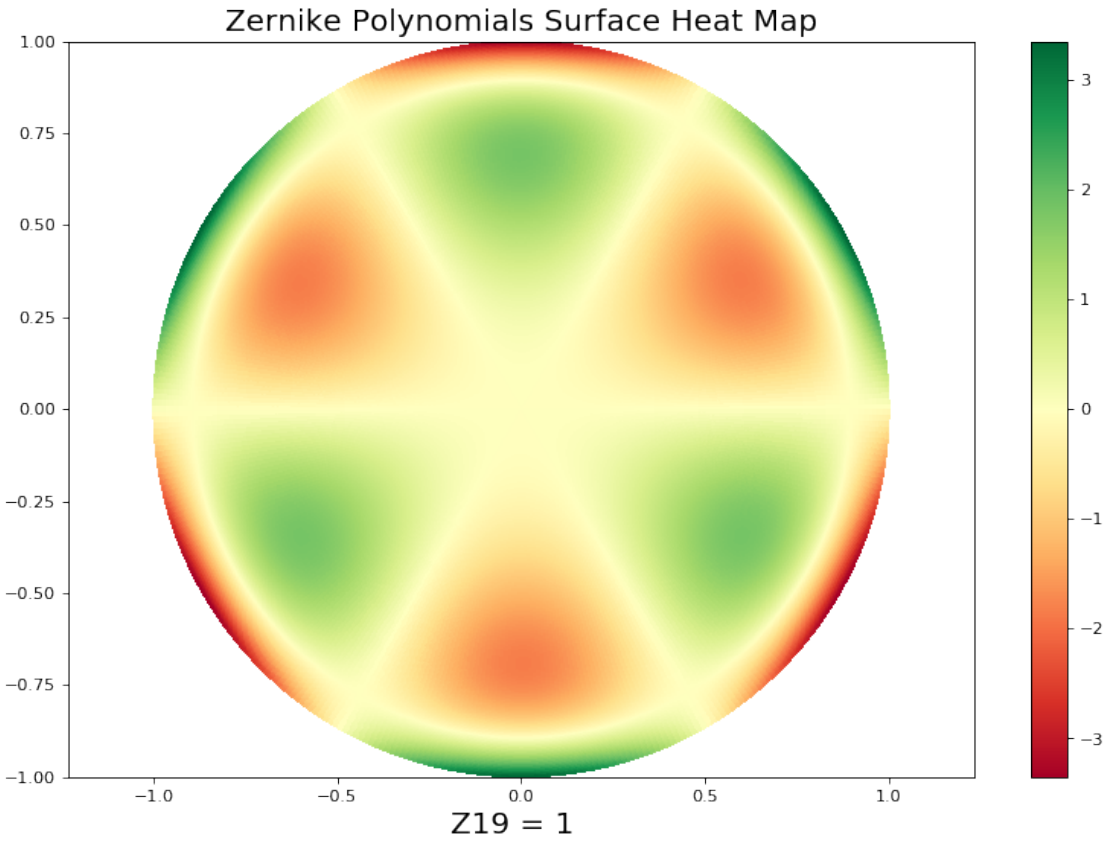
14
Z14 = 1 Z44 x Tetrafoil



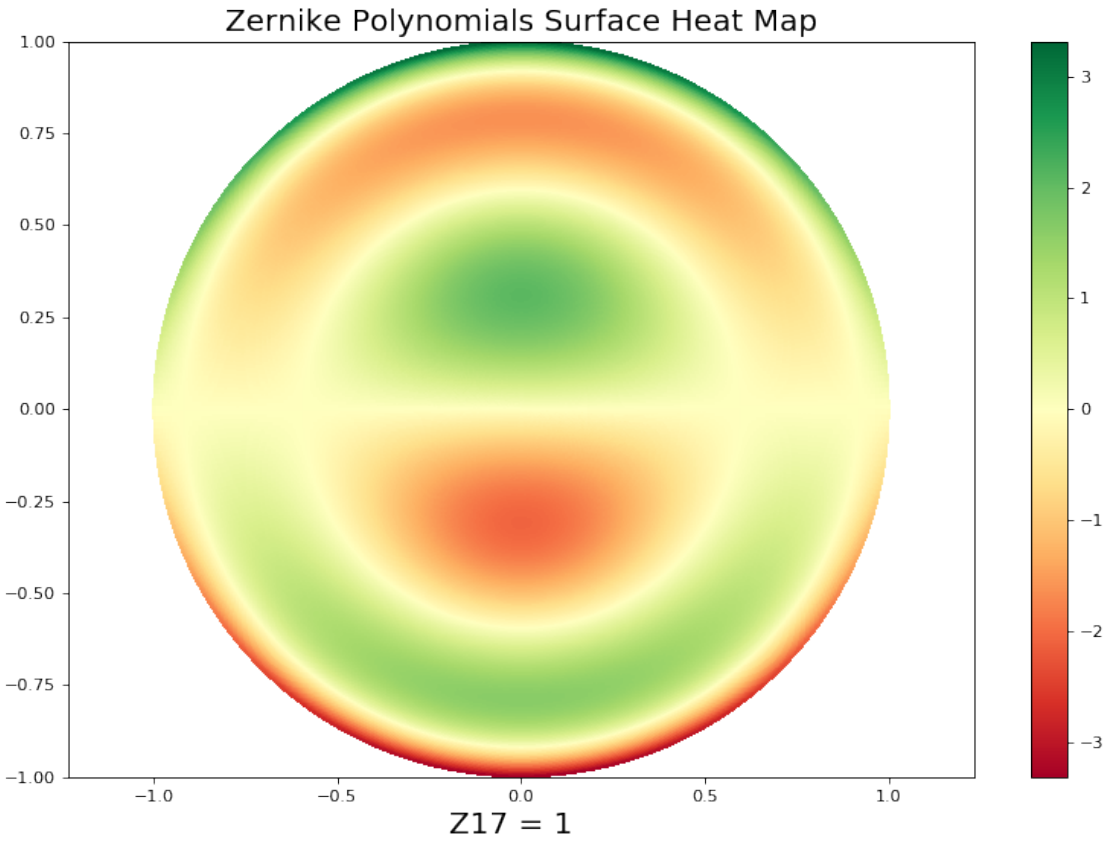
15
Z21 = 1 Z55 y Pentafoil



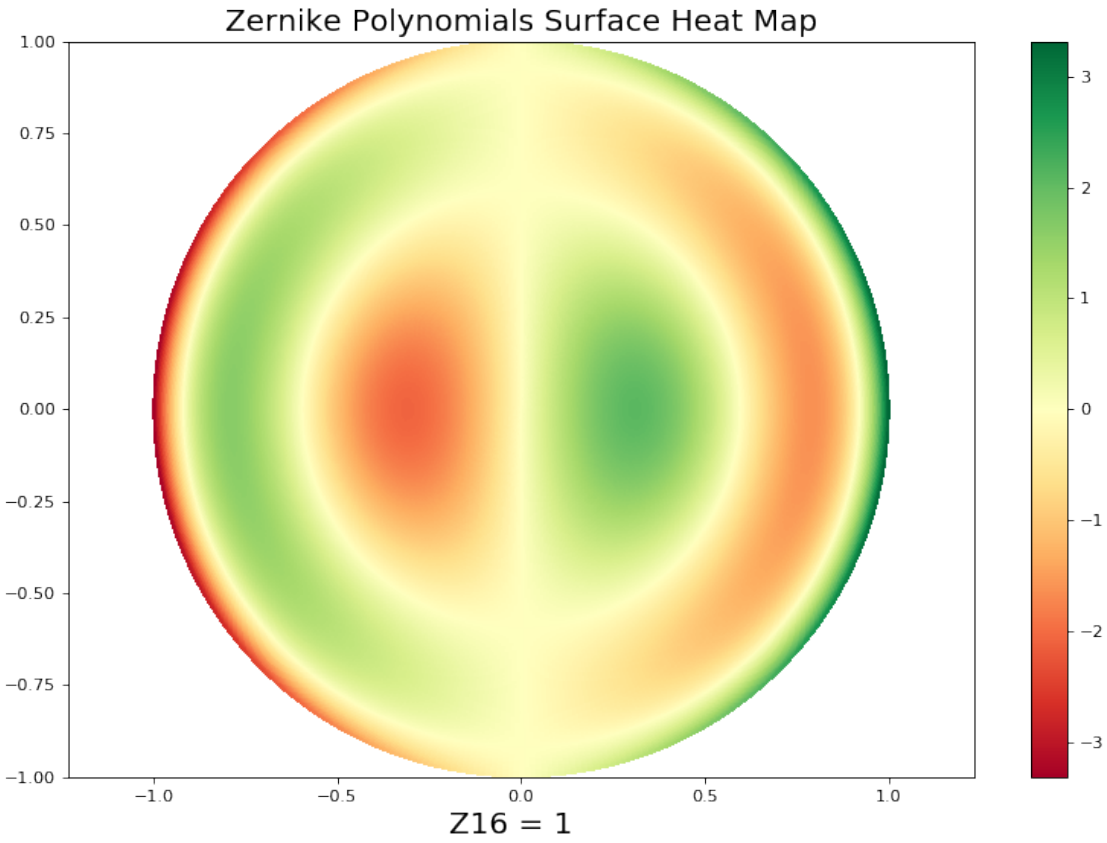
16
Z19 = 1 Z53 Secondary y Trefoil



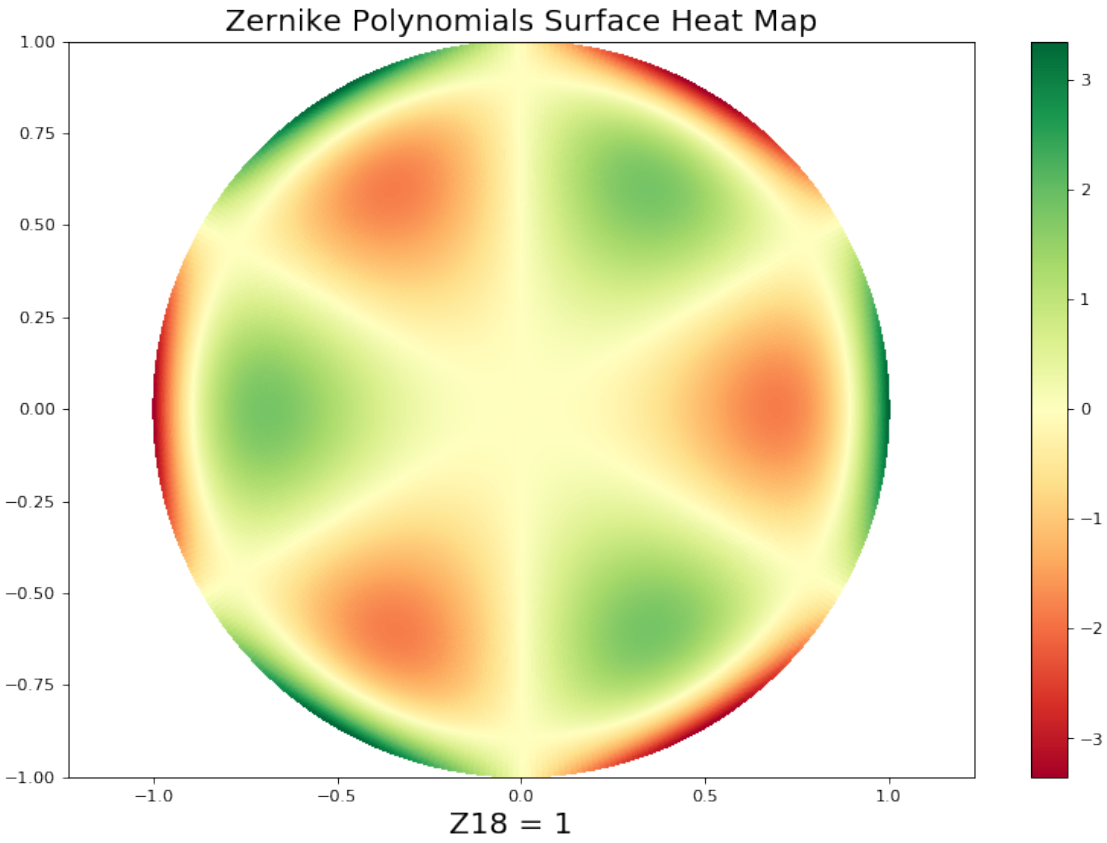
17
Z17 = 1 Z51 Secondary y Coma



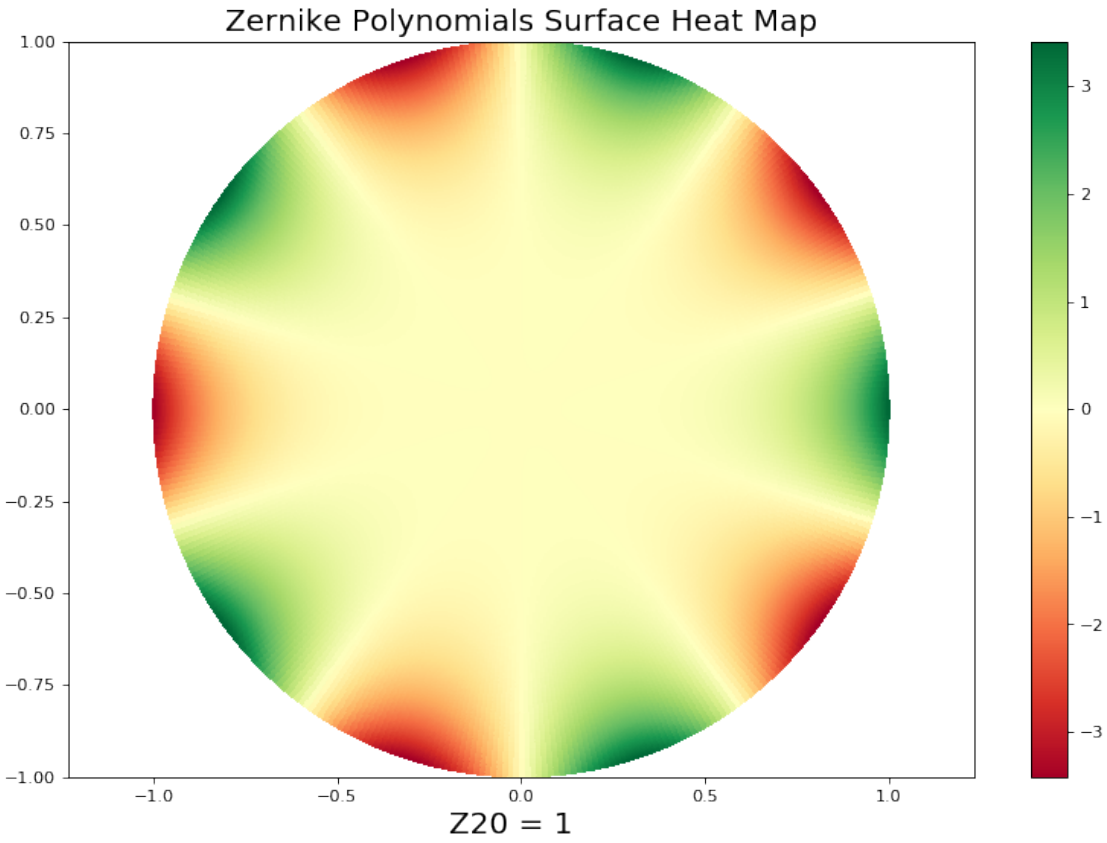
18
Z16 = 1 Z51 Secondary x Coma



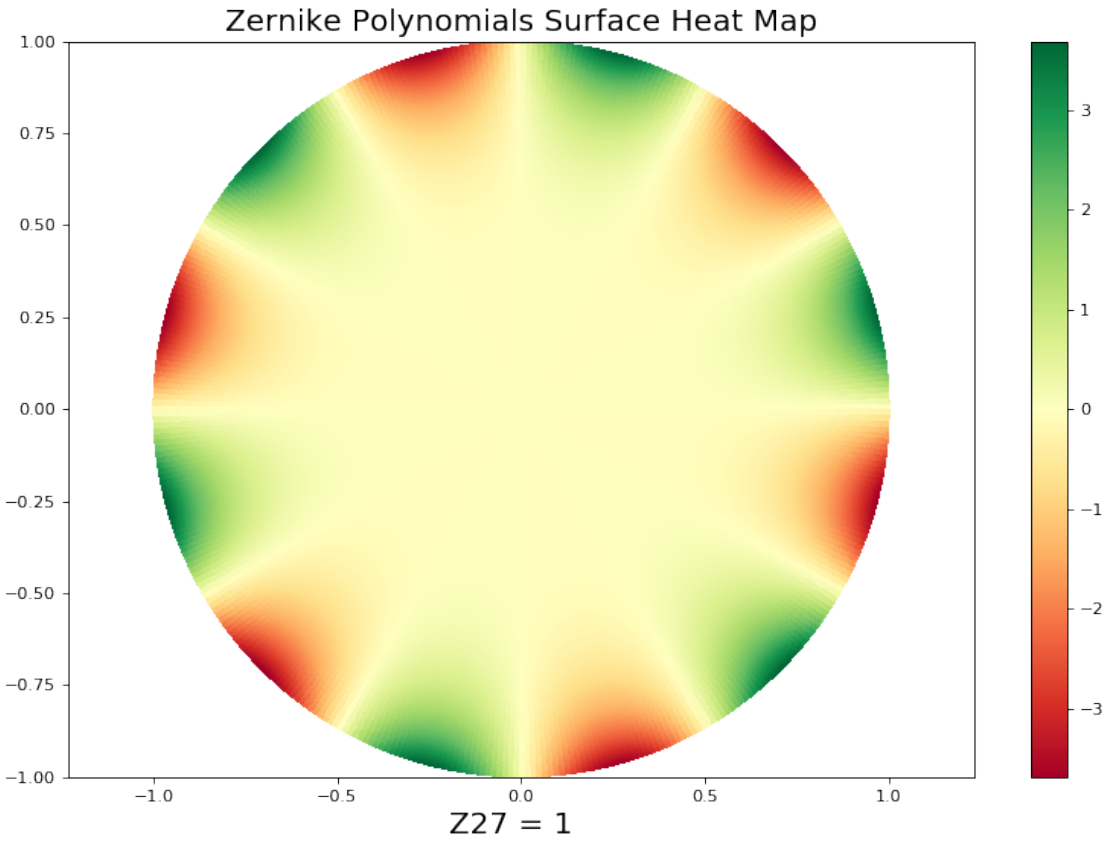
19
Z18 = 1 Z53 Secondary x Trefoil



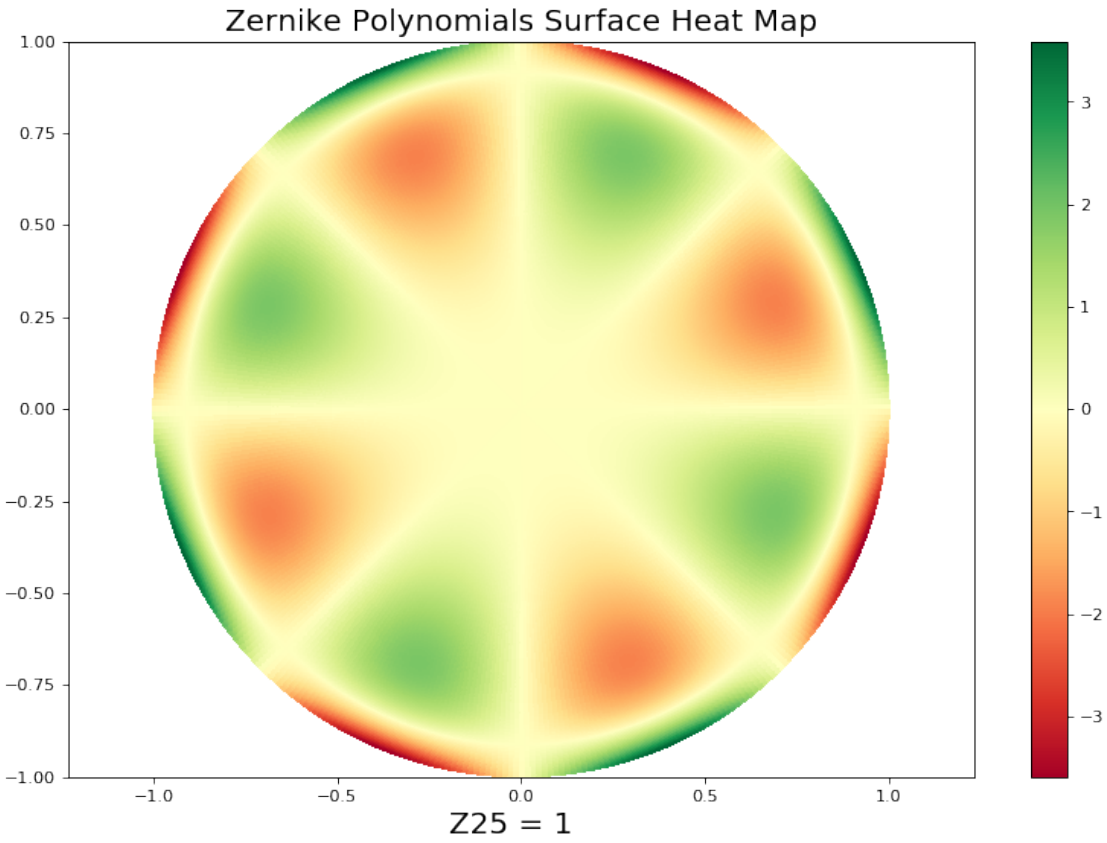
20
Z20 = 1 Z55 x Pentafoil



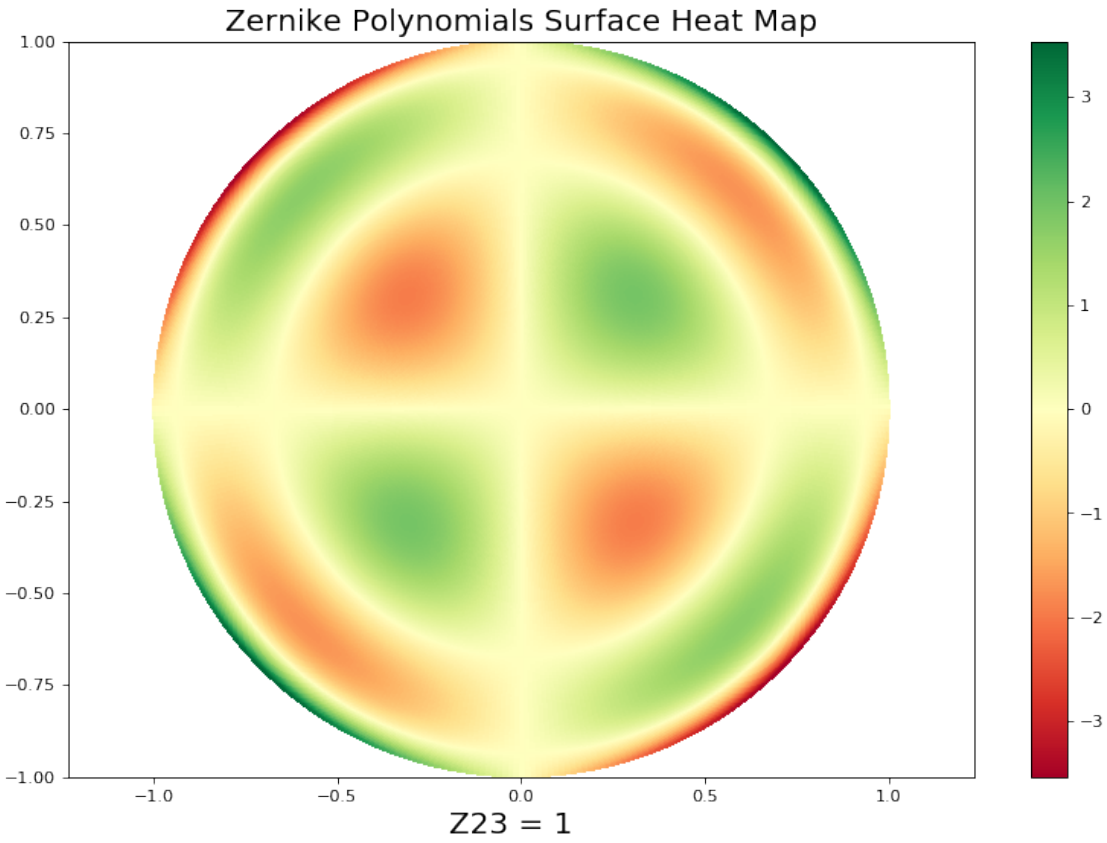
21
Z27 = 1 Z66 Hexafoil Y



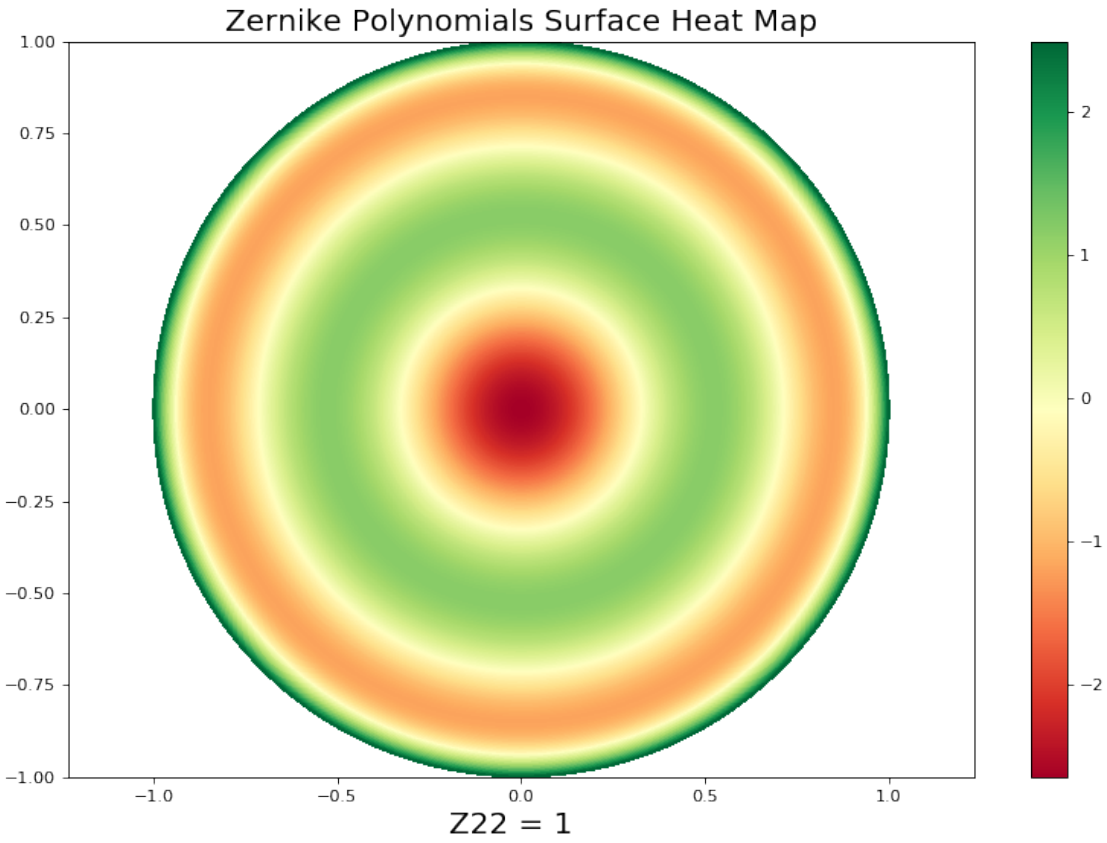
22
Z25 = 1 Z64 Secondary x Trefoil



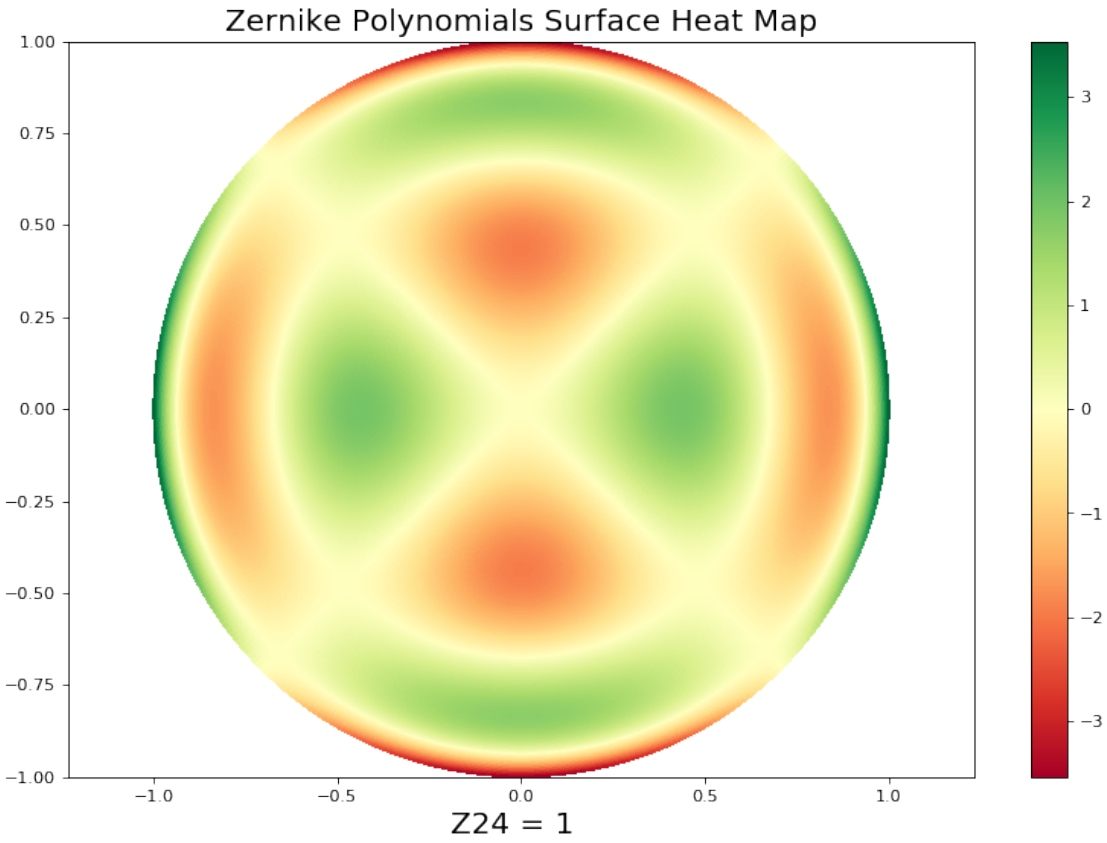
23
Z23 = 1 Z62 Tertiary Astigmatism at 45



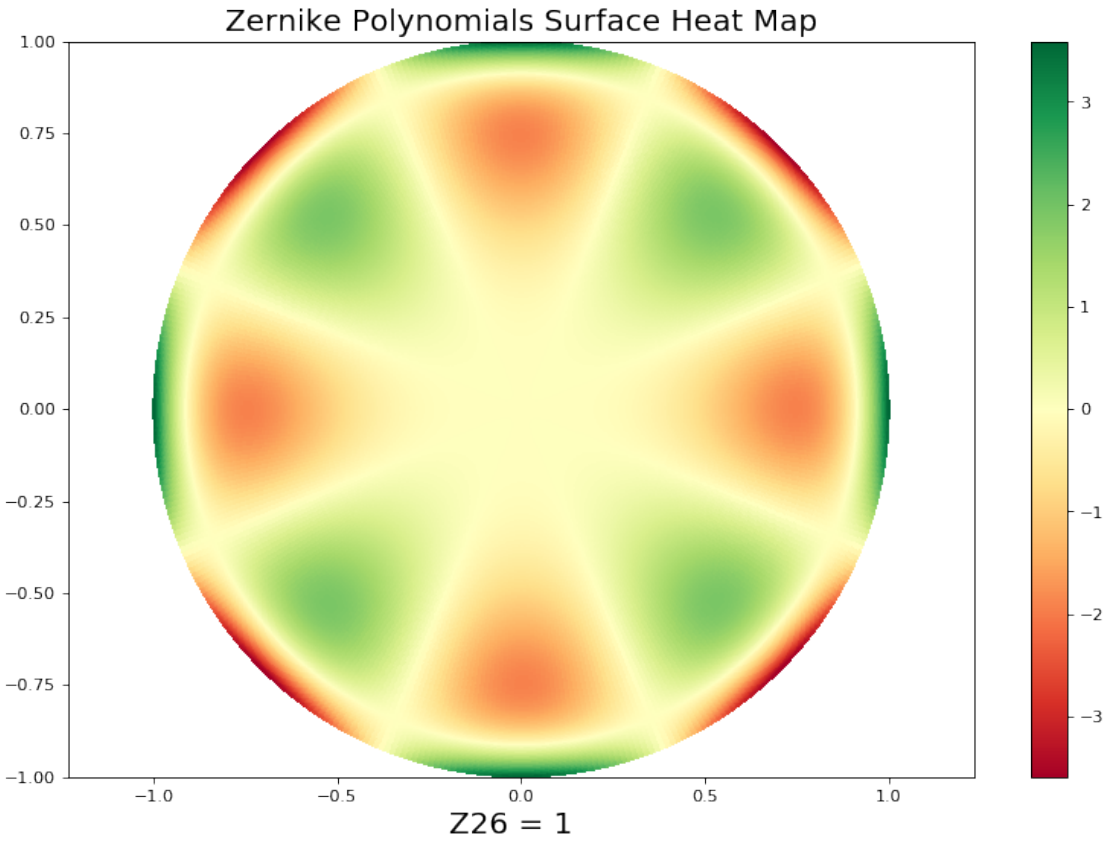

```
24
Z22 =  1 Z60 Secondary Spherical
```




```
25
Z24 =  1 Z62 Tertiary Astigmatism at 0
```

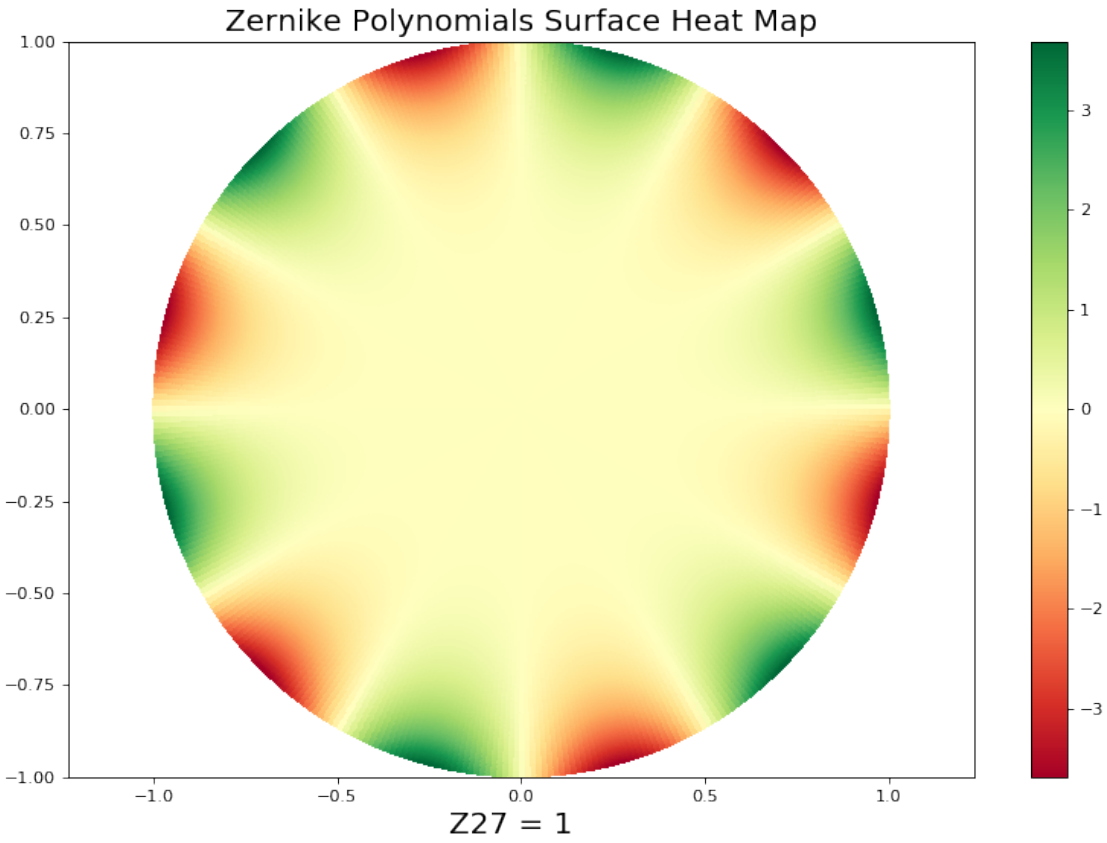



```
26
Z26 =  1 Z64 Secondary y Trefoil
```

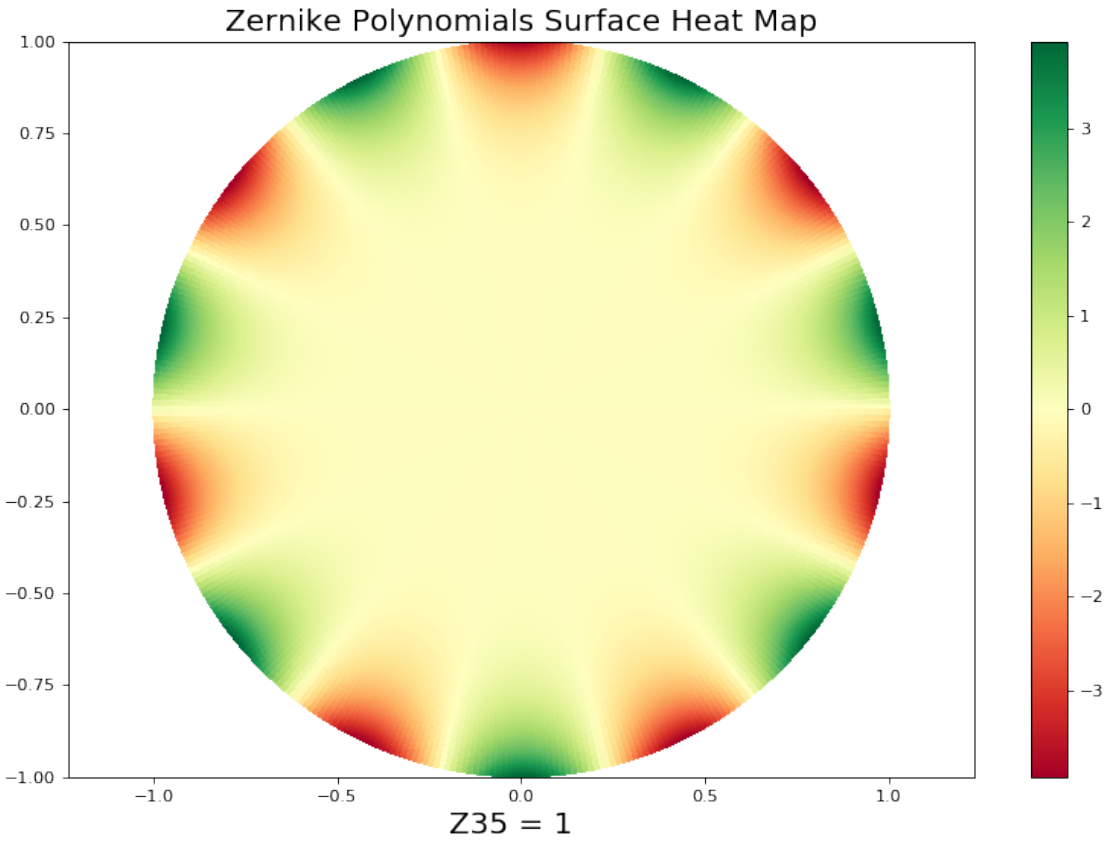


27

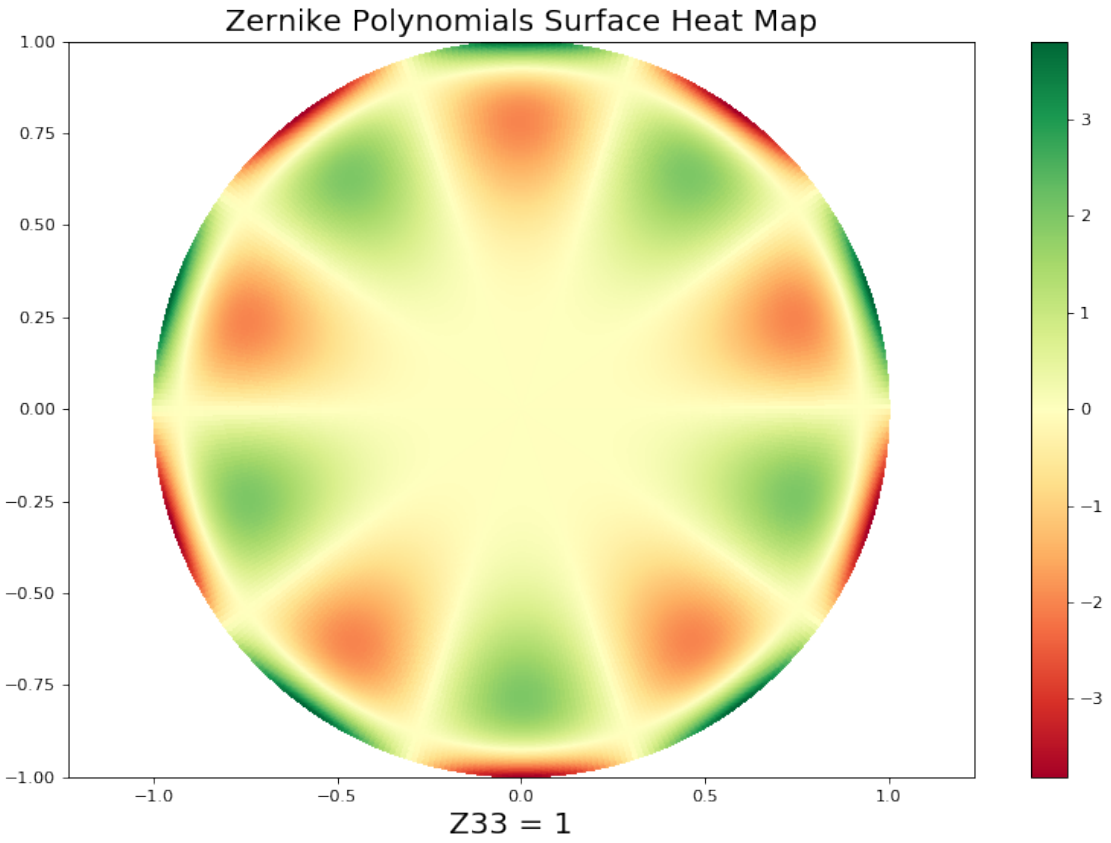
Z27 = 1 Z66 Hexafoil Y



28
Z35 = 1 Z77 Heptafoil Y

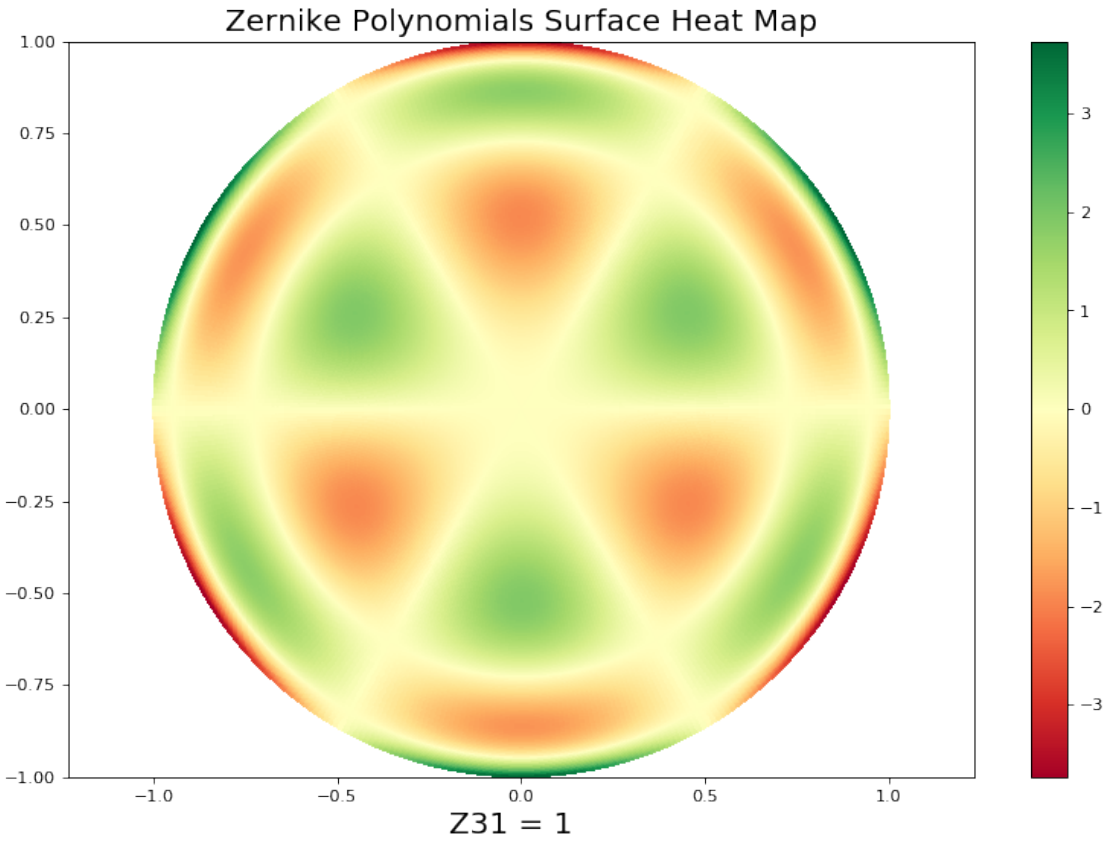


29
Z33 = 1 Z75 Secondary Pentafoil Y

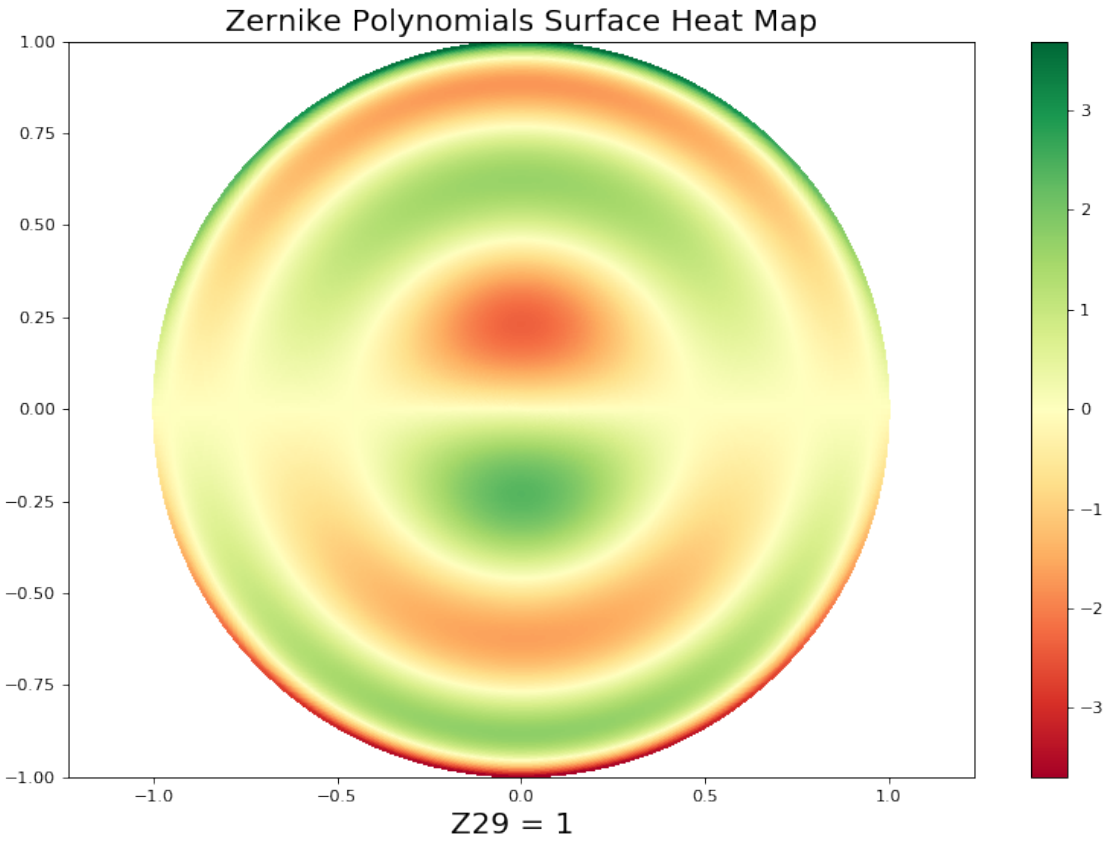


30

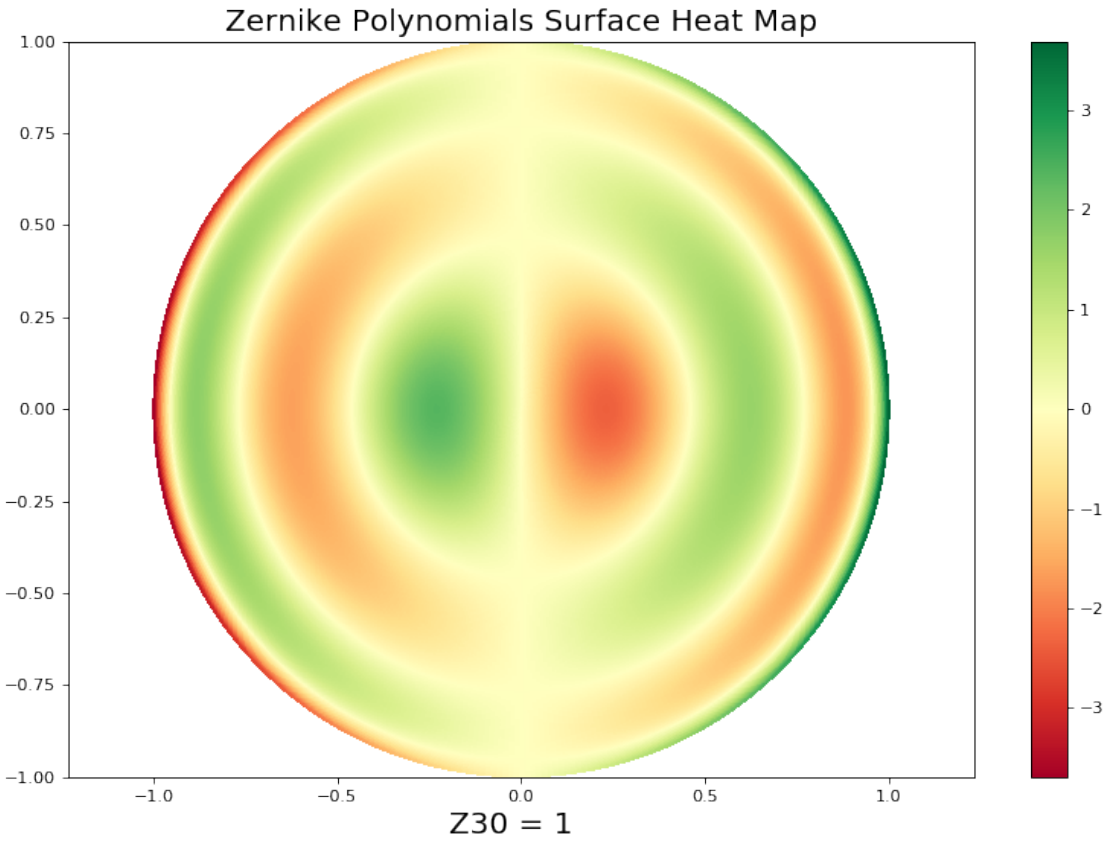
Z31 = 1 Z73 Tertiary y Trefoil



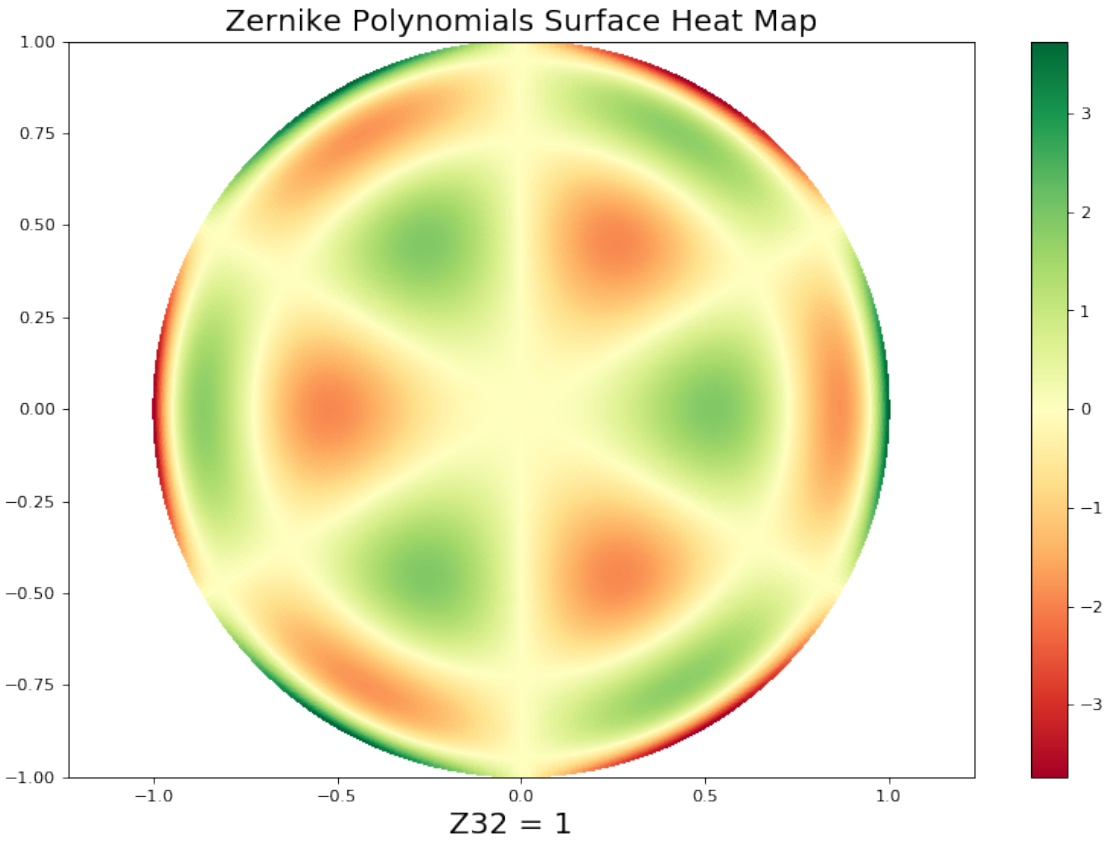
31
Z29 = 1 Z71 Tertiary y Coma



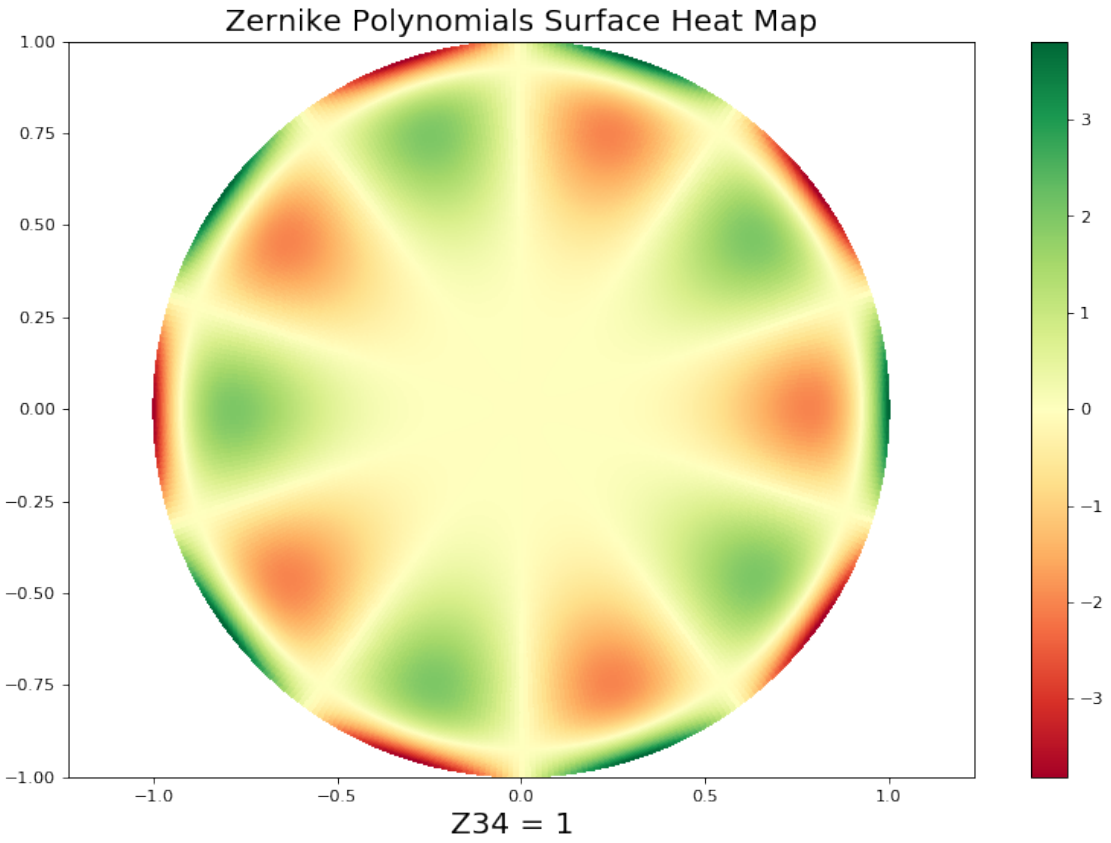
32
Z30 = 1 Z71 Tertiary x Coma



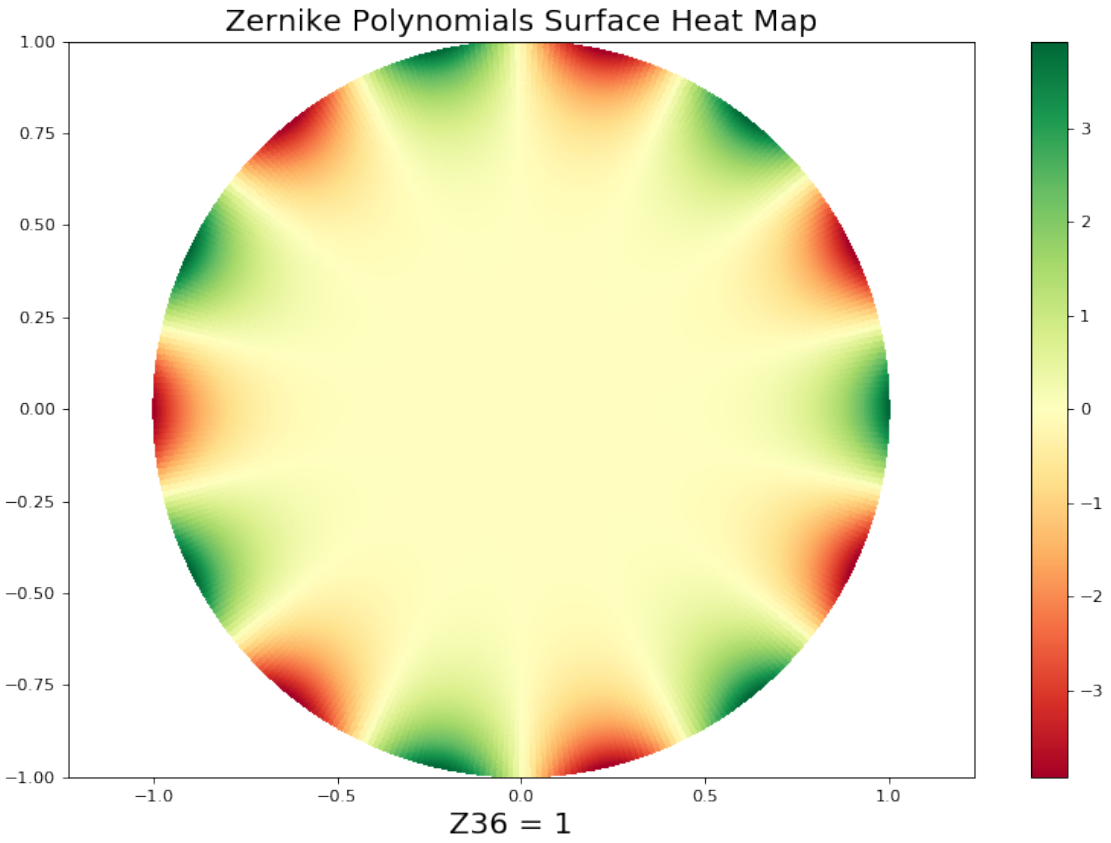
33
Z32 = 1 Z73 Tertiary x Trefoil



34
Z34 = 1 Z75 Secondary Pentafoil X



35
Z36 = 1 Z77 Heptafoil X

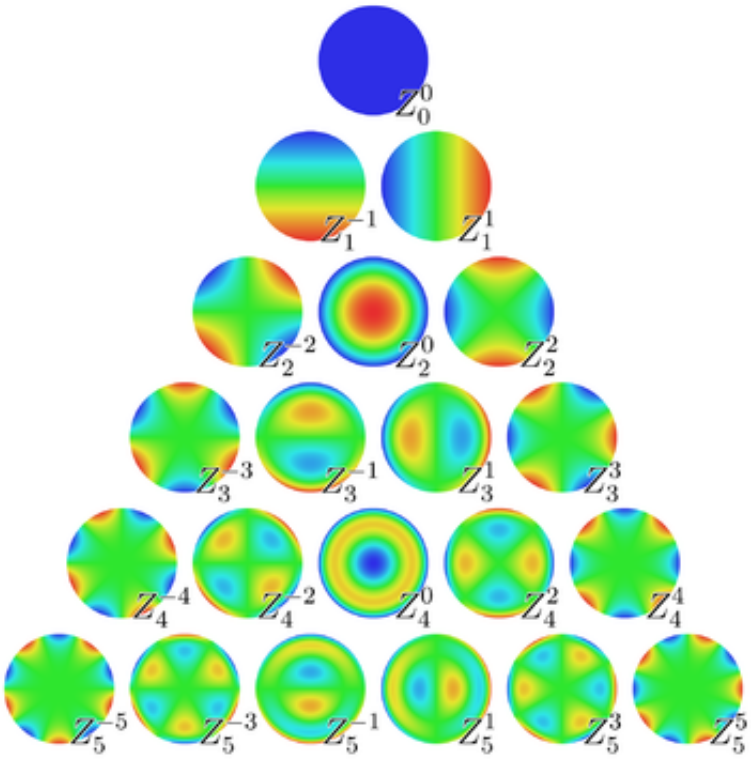


1.2 Make sure new order matches ANSI order

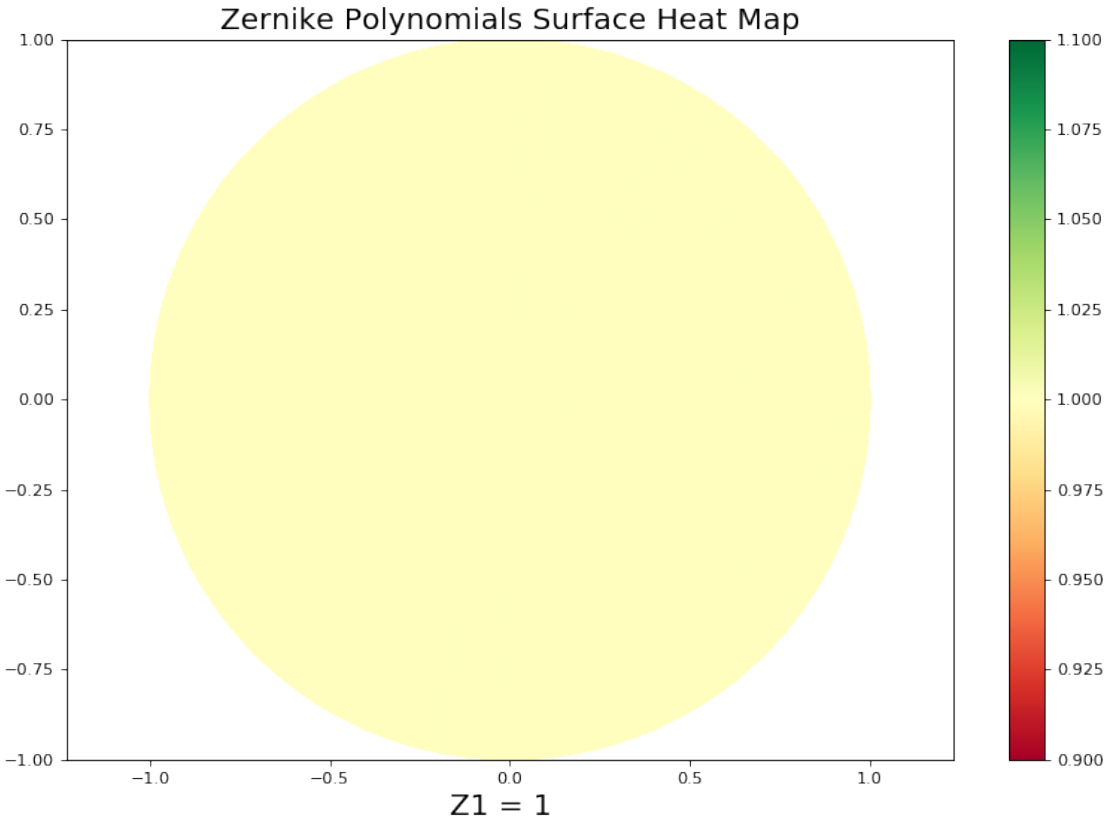
```
In [6]: # now convert the original NOLL indicies to what the Active Surface expects
        asAnsiZs = noll2asAnsi(zs)

In [7]: # plot the new ordering
        for i, z in enumerate(asAnsiZs):
            print i; z.zernikemap()
```

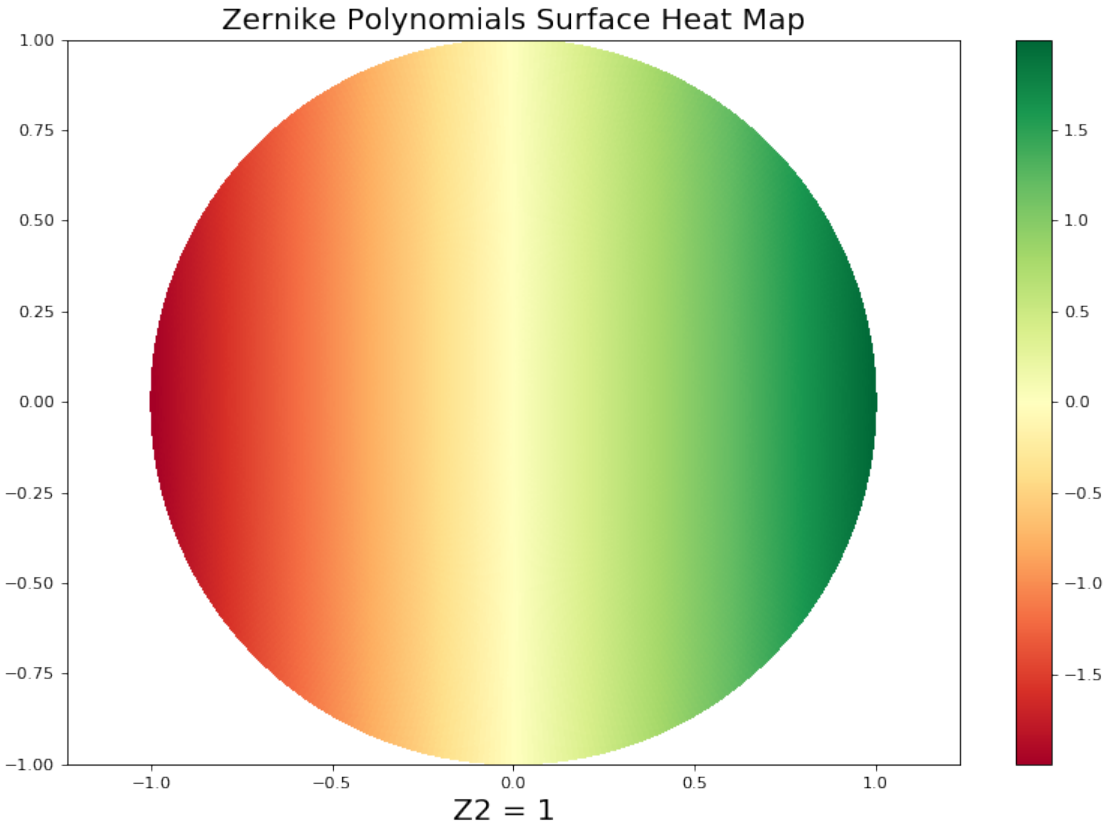
```
0
Z1 =  1 Z00 Piston or Bias
```


Z_0^0
Z_1^{-1}
Z_1^1
Z_2^{-2}
Z_2^0
Z_2^2
Z_3^{-3}
Z_3^{-1}
Z_3^1
Z_3^3
Z_4^{-4}
Z_4^{-2}
Z_4^0
Z_4^2
Z_4^4
Z_5^{-5}
Z_5^{-3}
Z_5^{-1}
Z_5^1
Z_5^3
Z_5^5

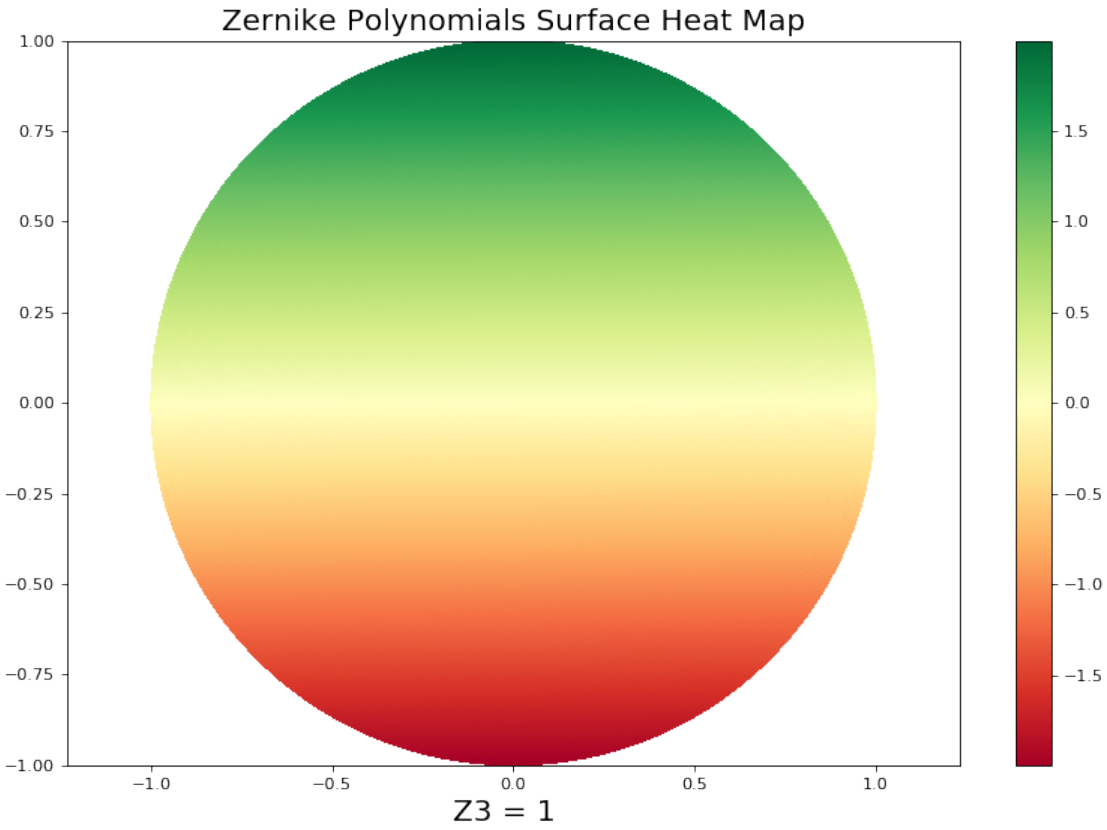
ansi


Zernike Polynomials Surface Heat Map
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.0
−0.5
0.0
0.5
1.0
1.100
1.075
1.050
1.025
1.000
0.975
0.950
0.925
0.900
Z1 = 1

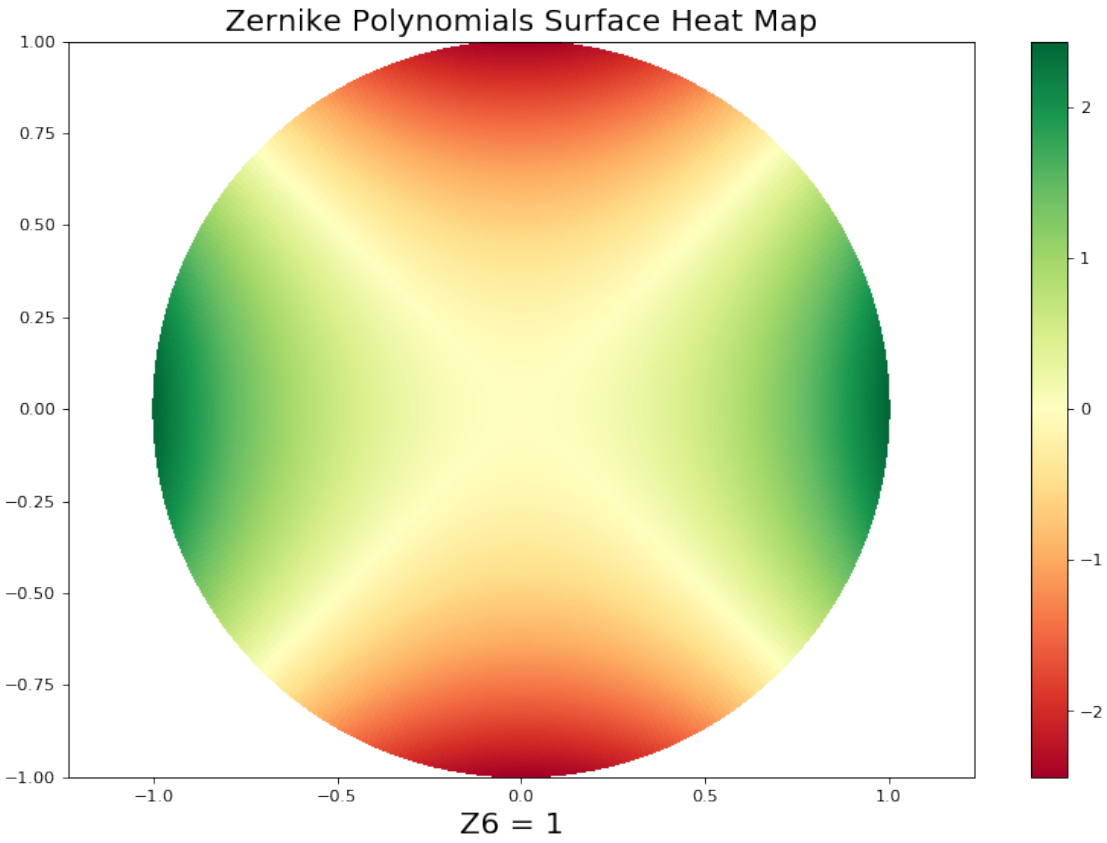
1
Z2 = 1 Z11 x Tilt



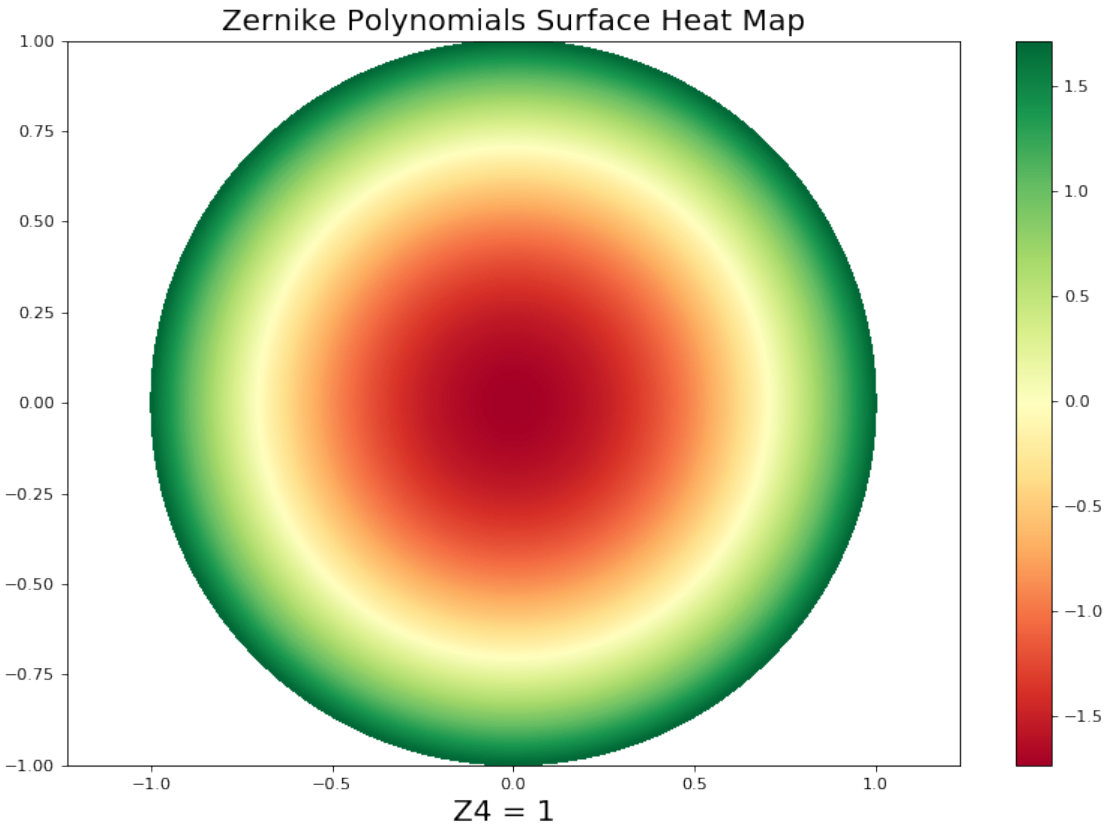
2
Z3 = 1 Z11 y Tilt



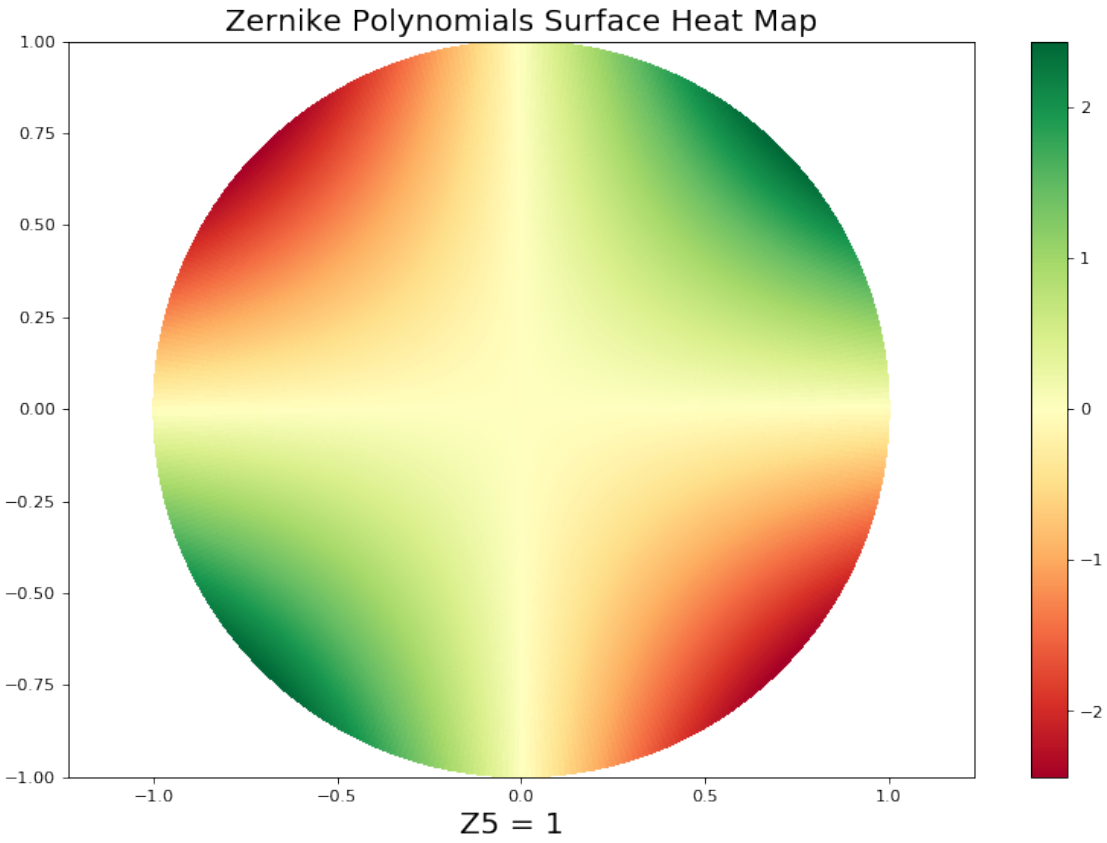

```
3
Z6 =  1 Z22 Primary Astigmatism at 0
```



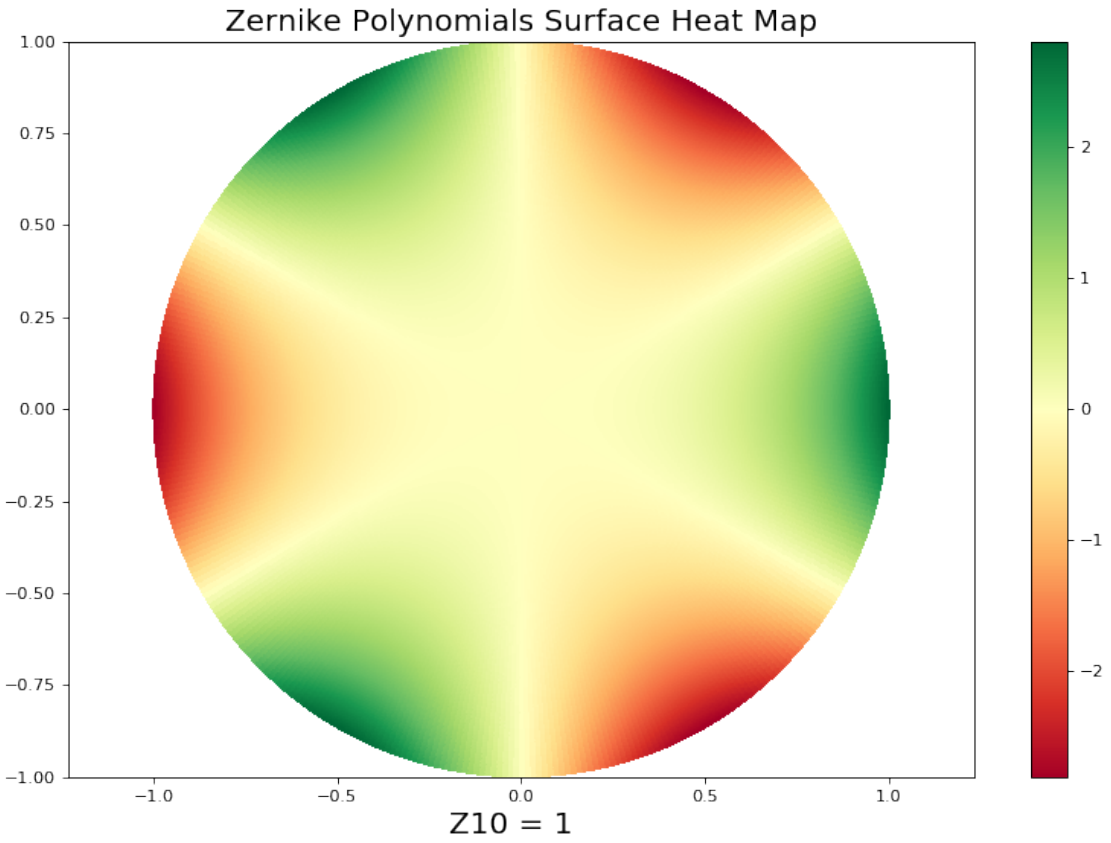

```
4
Z4 =  1 Z20 Defocus
```



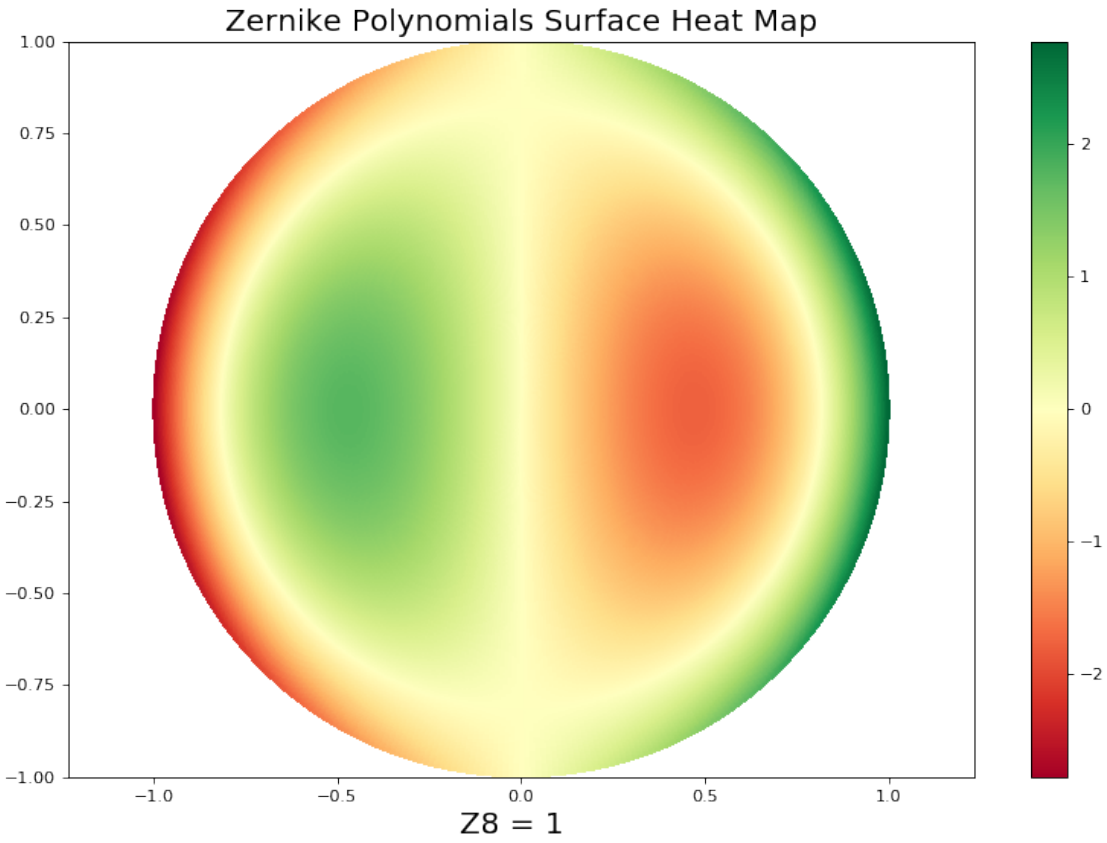

```
5
Z5 =  1 Z22 Primary Astigmatism at 45
```



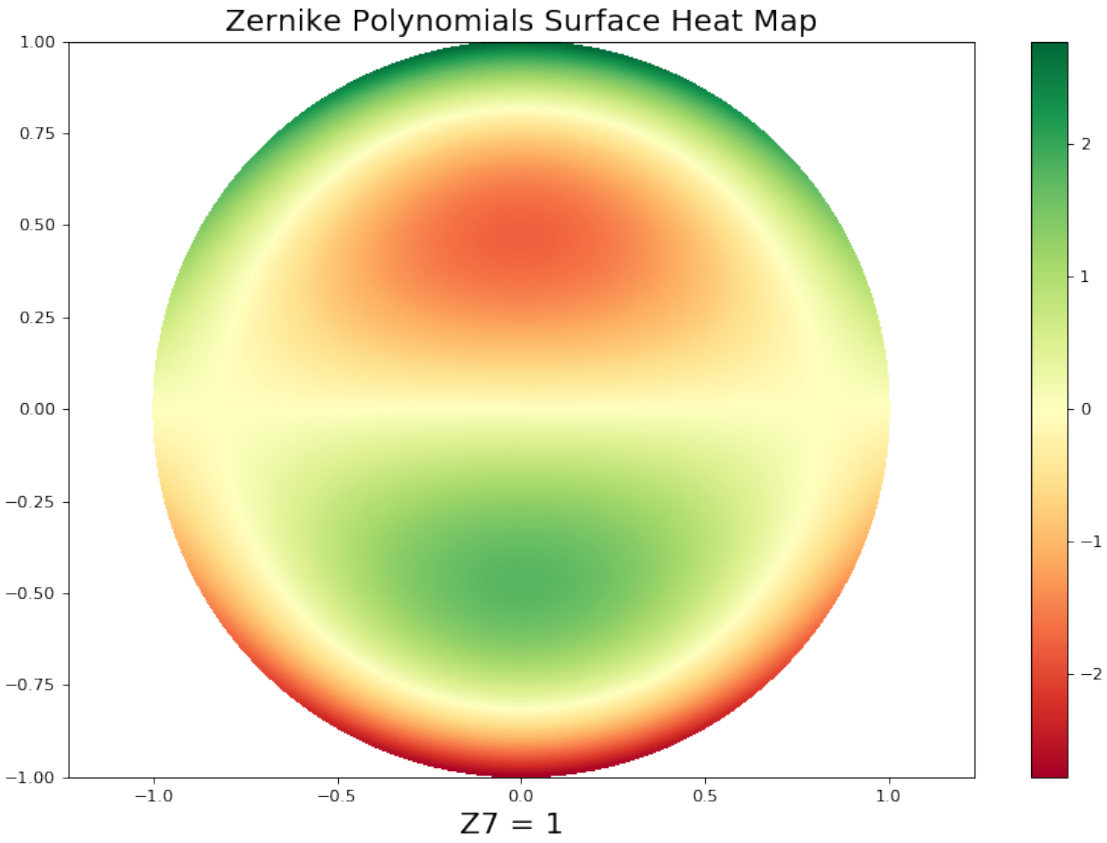
6
Z10 = 1 Z33 x Trefoil



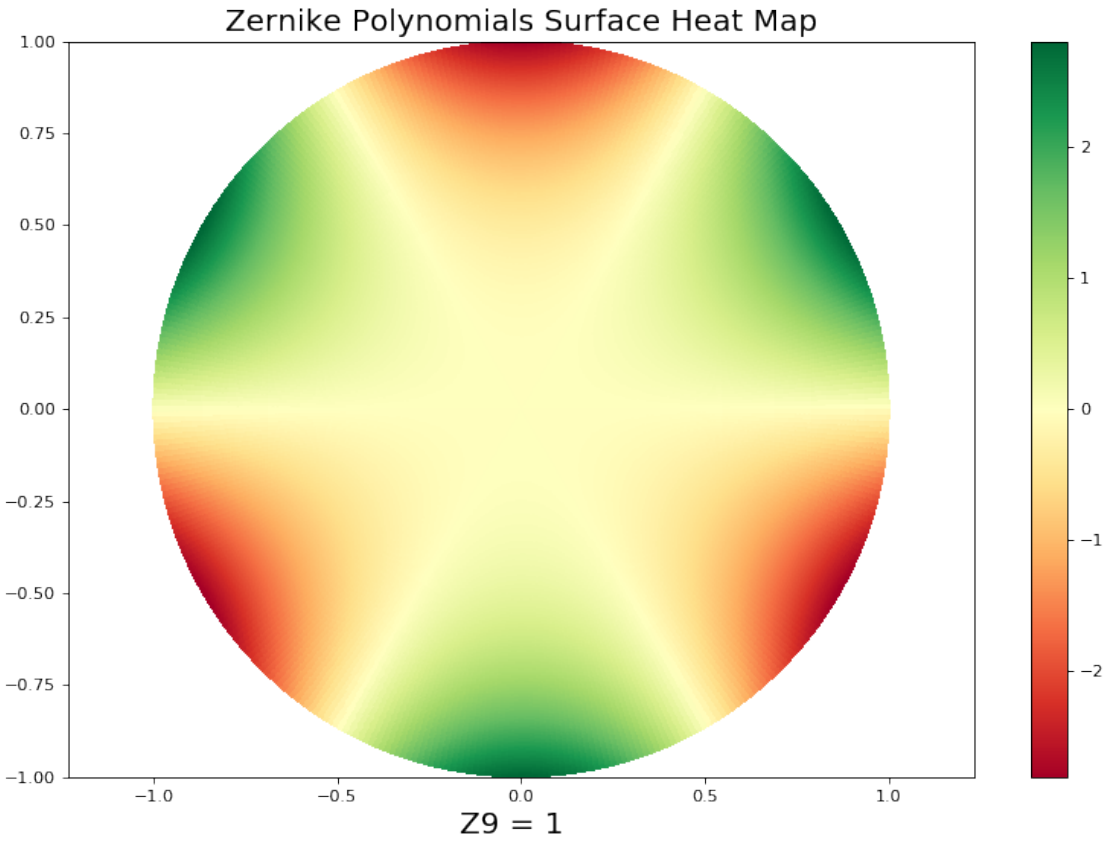
7
Z8 = 1 Z31 Primary x Coma



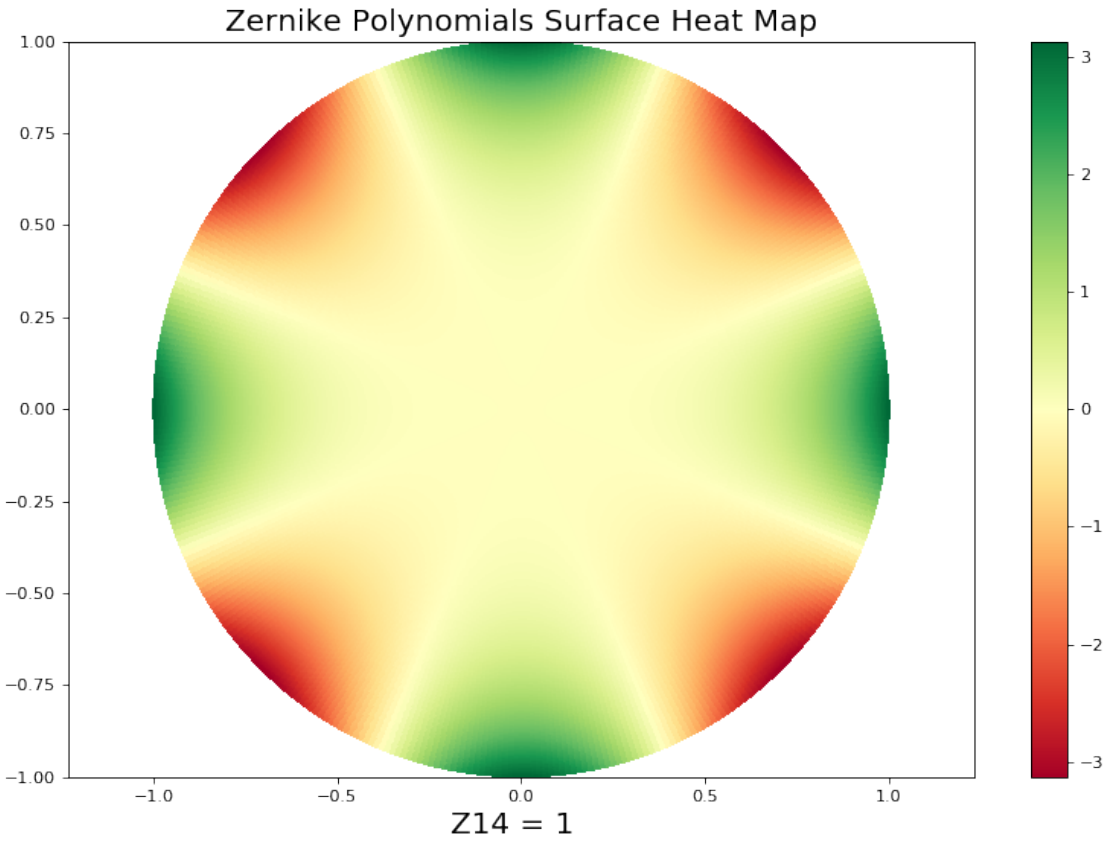
8
Z7 = 1 Z31 Primary y Coma



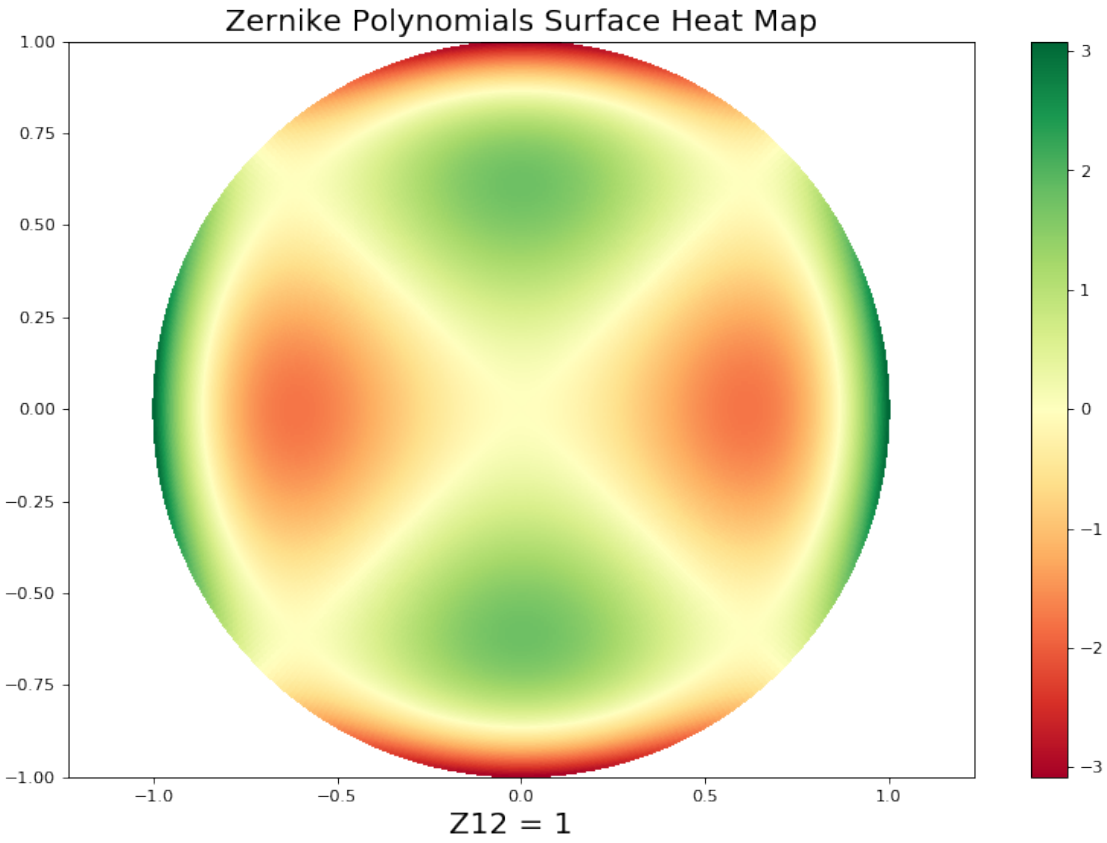
9
Z9 = 1 Z33 y Trefoil



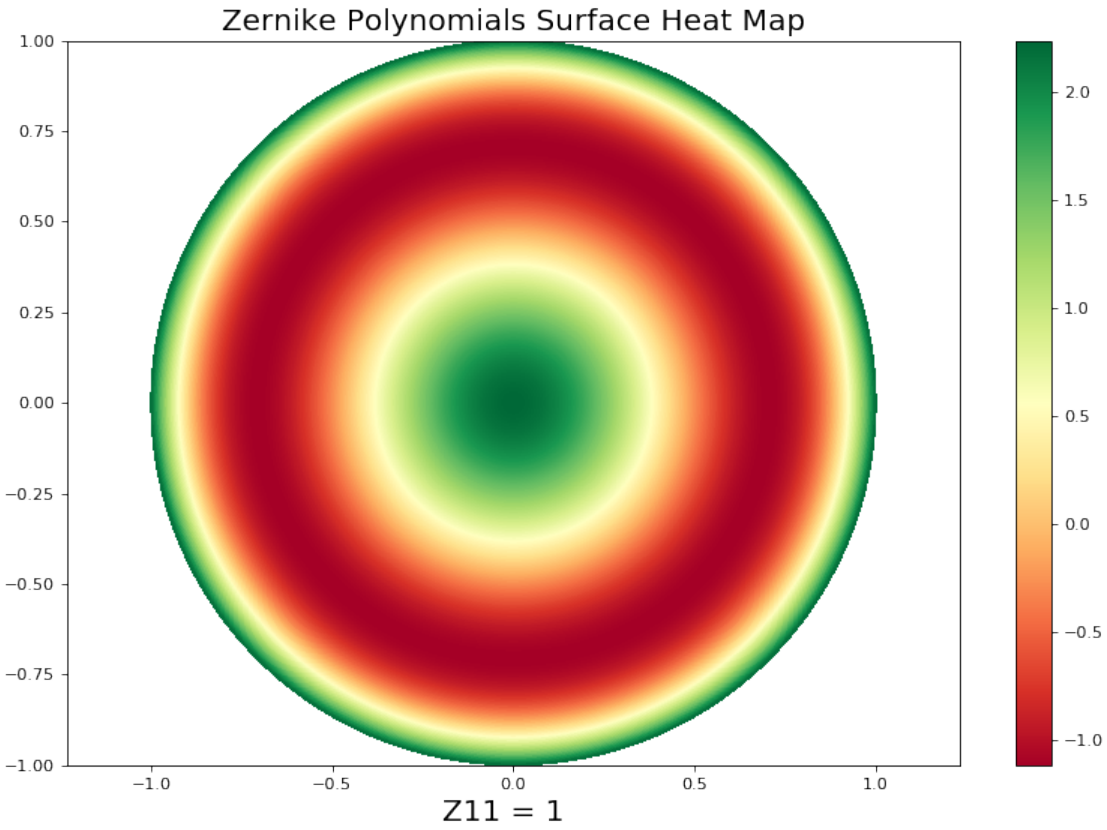
10
Z14 = 1 Z44 x Tetrafoil



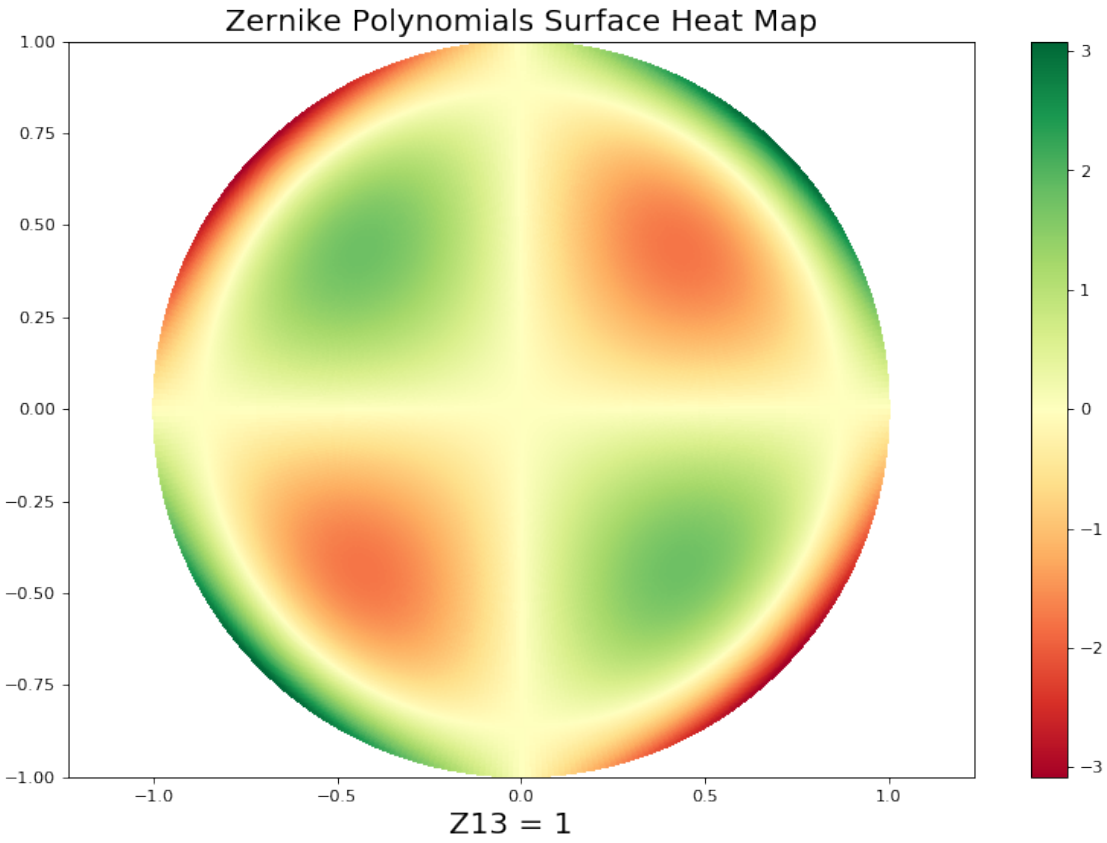

```
11
Z12 =  1 Z42 Secondary Astigmatism at 0
```



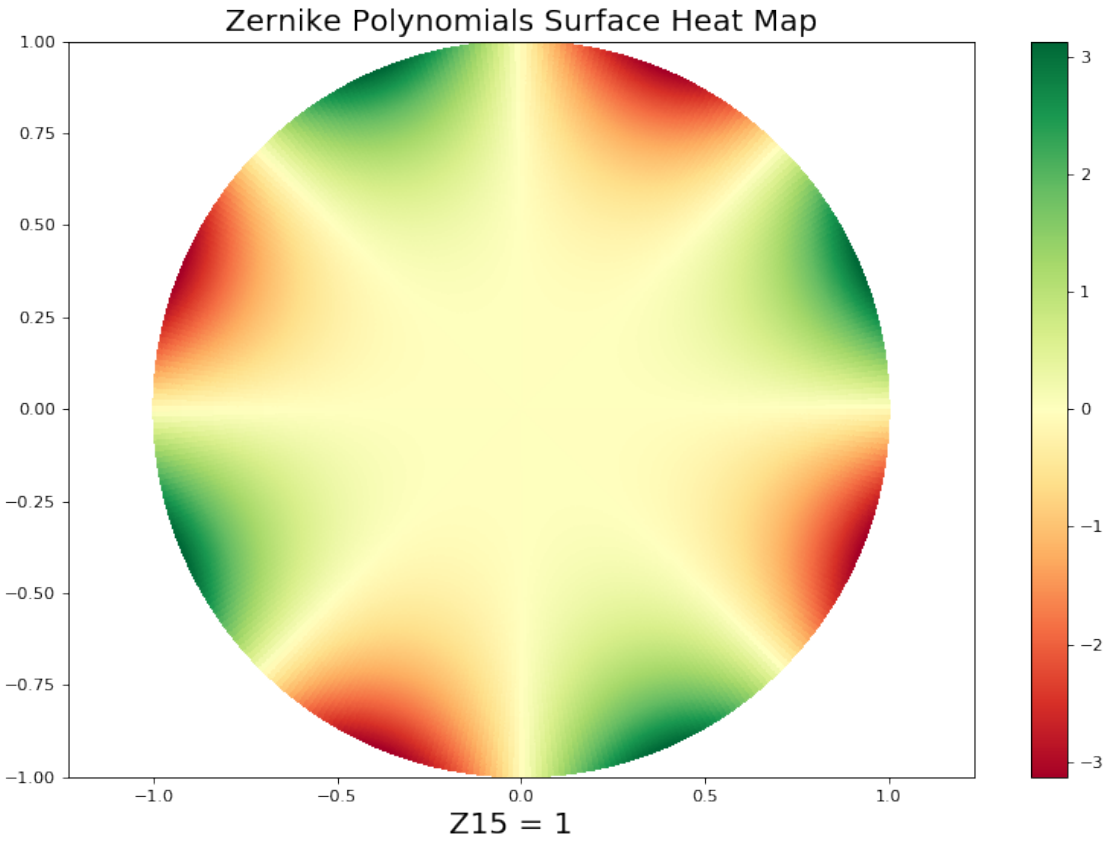

```
12
Z11 =  1 Z40 Primary Spherical
```



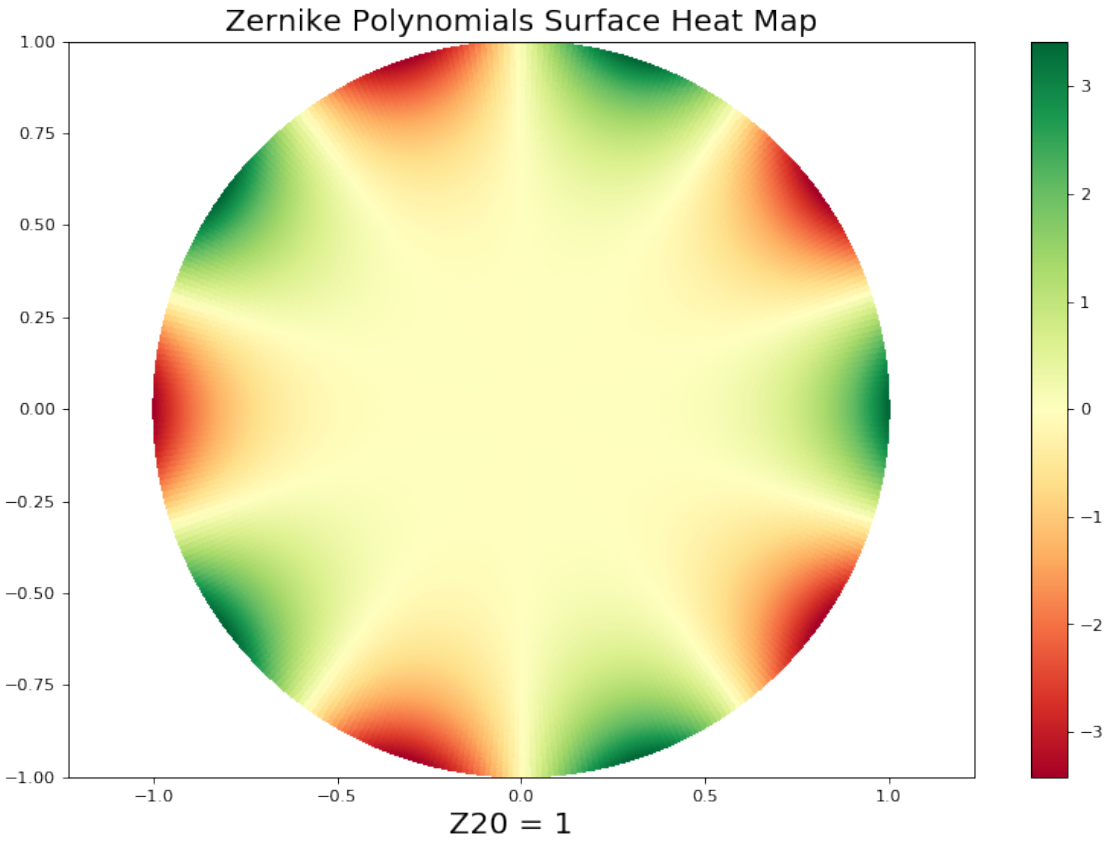
13
Z13 = 1 Z42 Secondary Astigmatism at 45



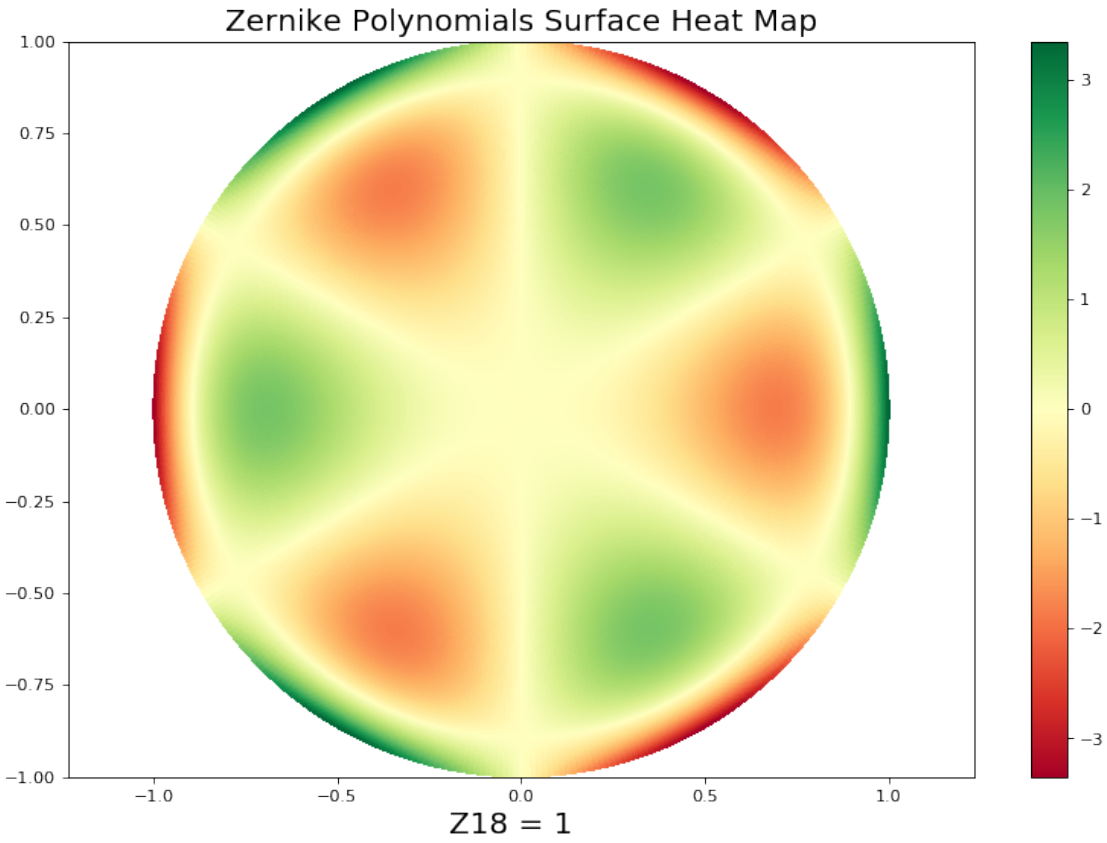
14
Z15 = 1 Z44 y Tetrafoil



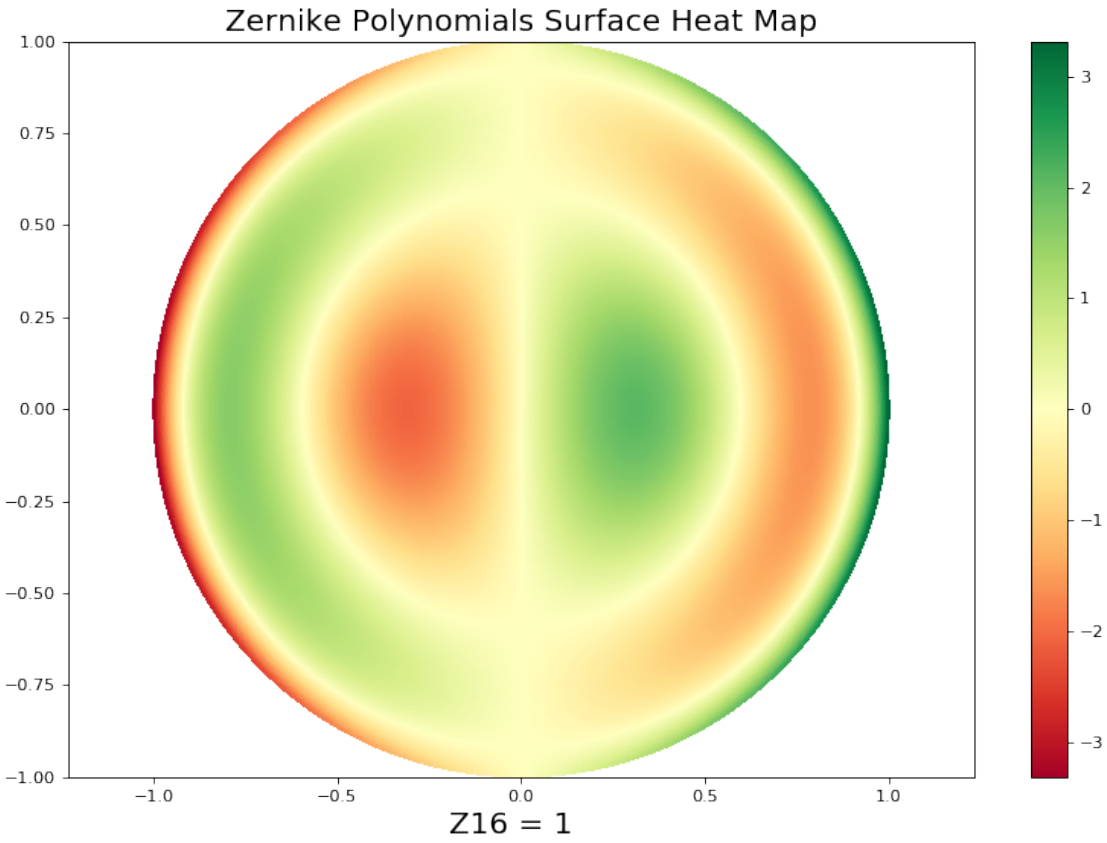
15
Z20 = 1 Z55 x Pentafoil



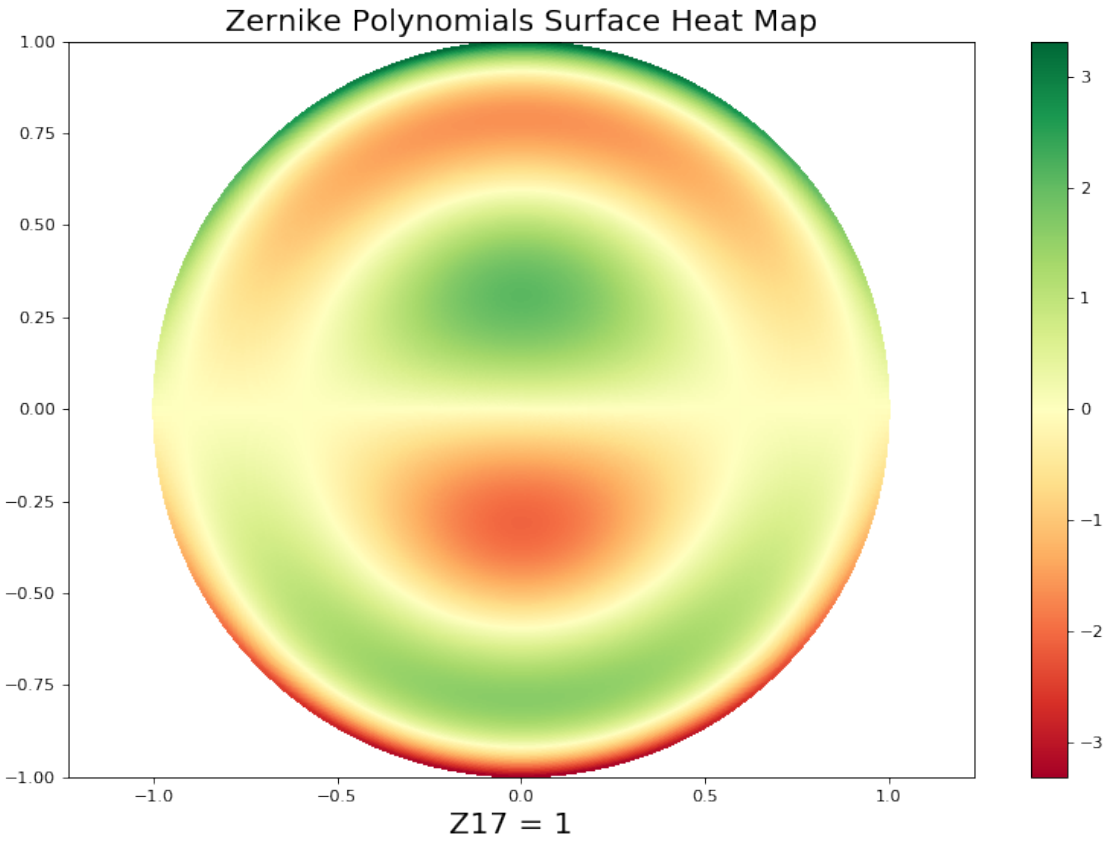
16
Z18 = 1 Z53 Secondary x Trefoil



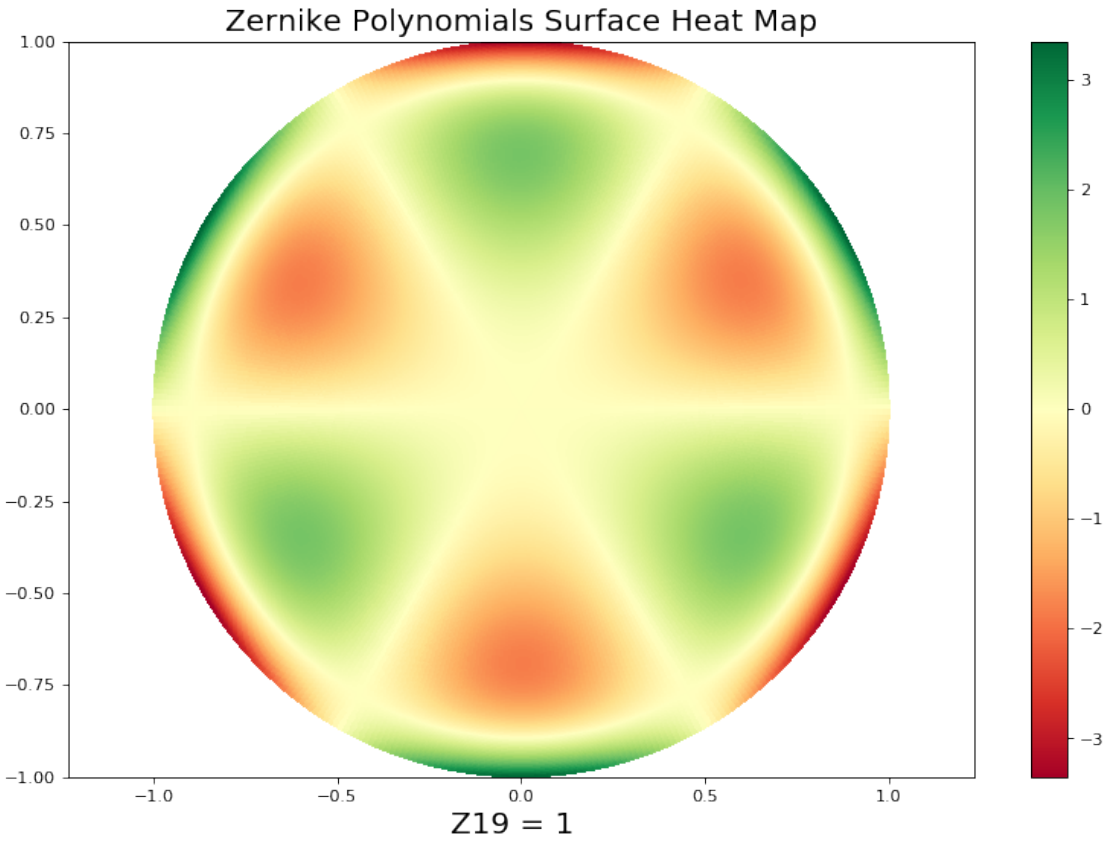
17
Z16 = 1 Z51 Secondary x Coma



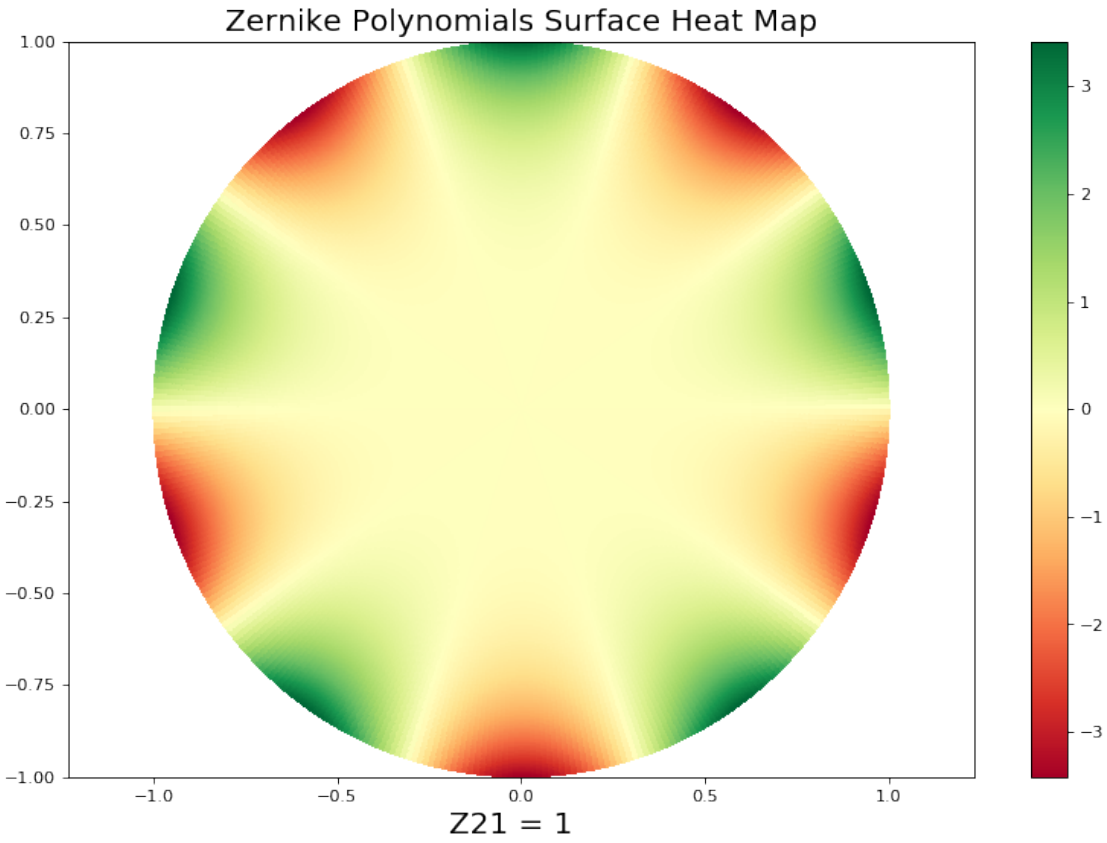
18
Z17 = 1 Z51 Secondary y Coma



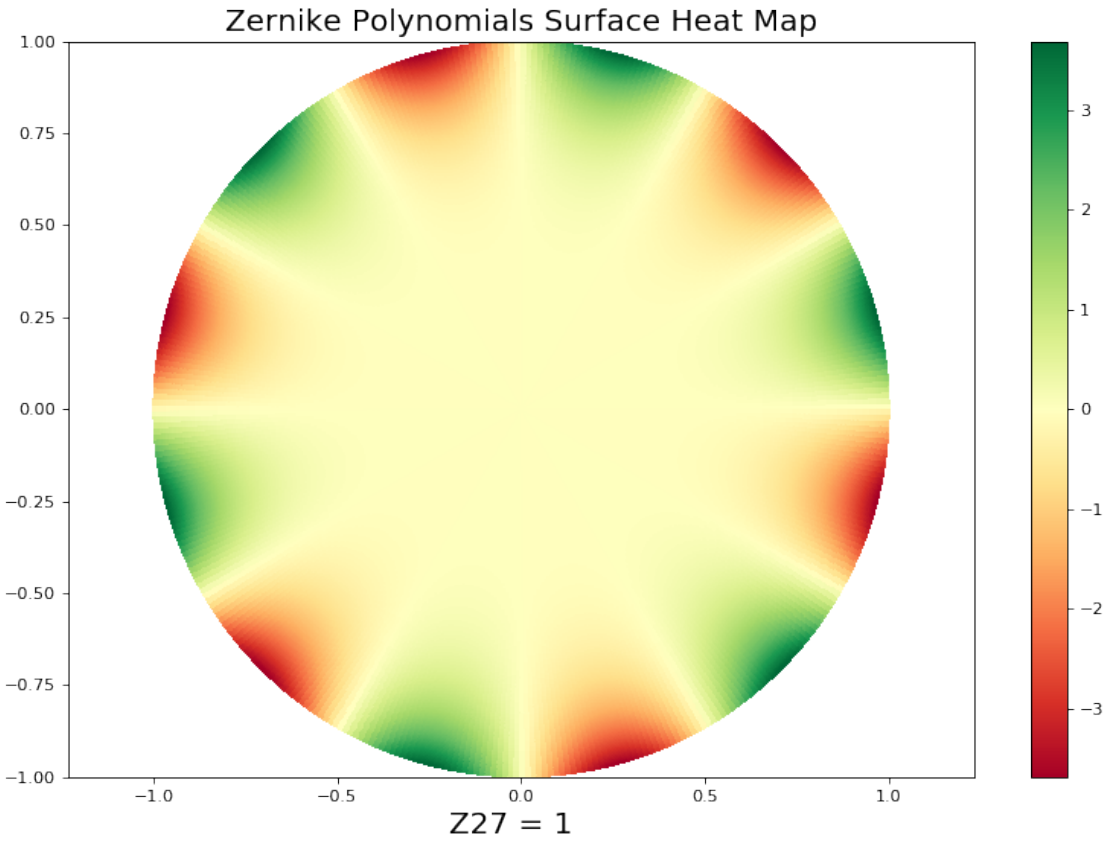
19
Z19 = 1 Z53 Secondary y Trefoil



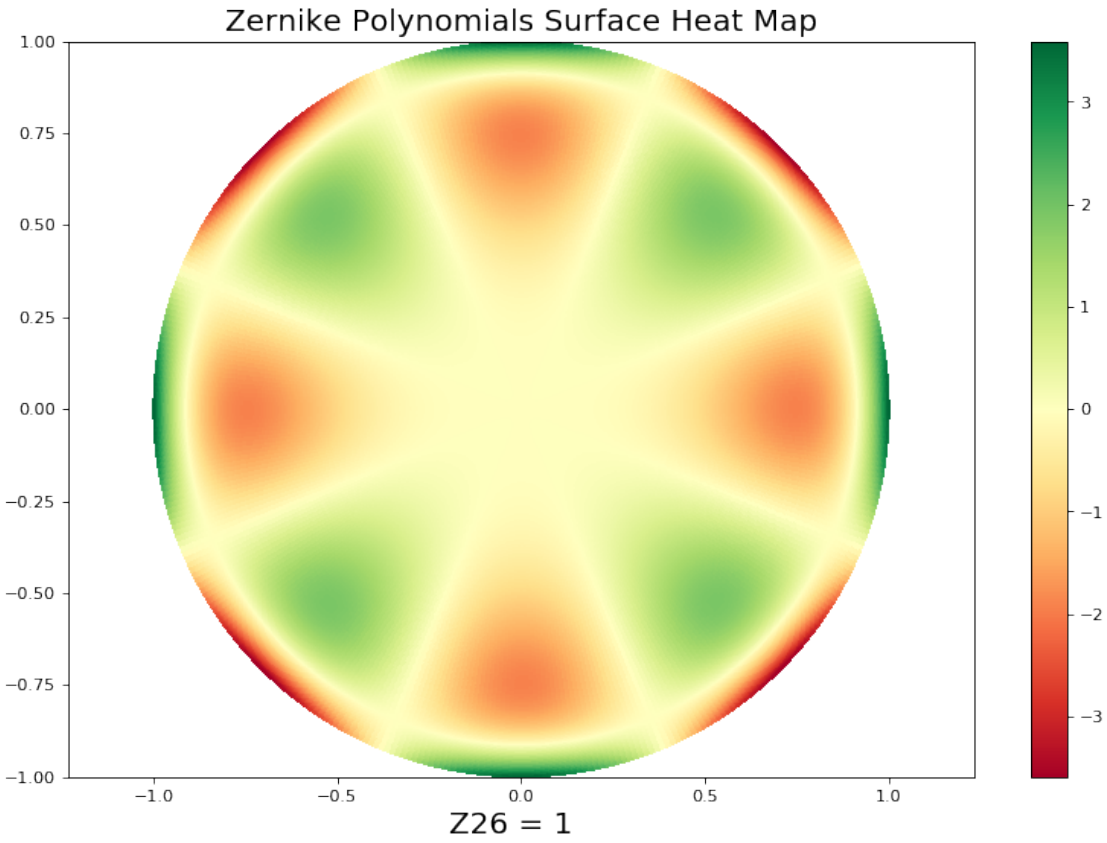
20
Z21 = 1 Z55 y Pentafoil



21
Z27 = 1 Z66 Hexafoil Y

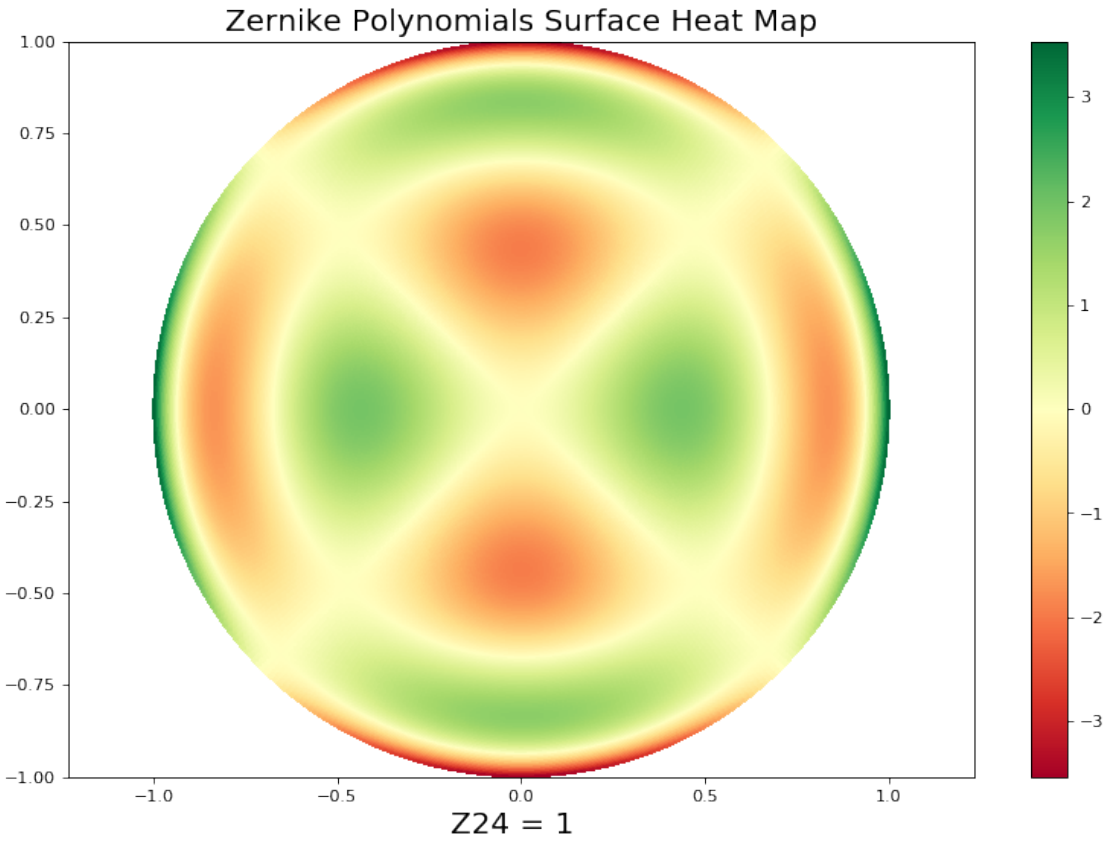


22
Z26 = 1 Z64 Secondary y Trefoil

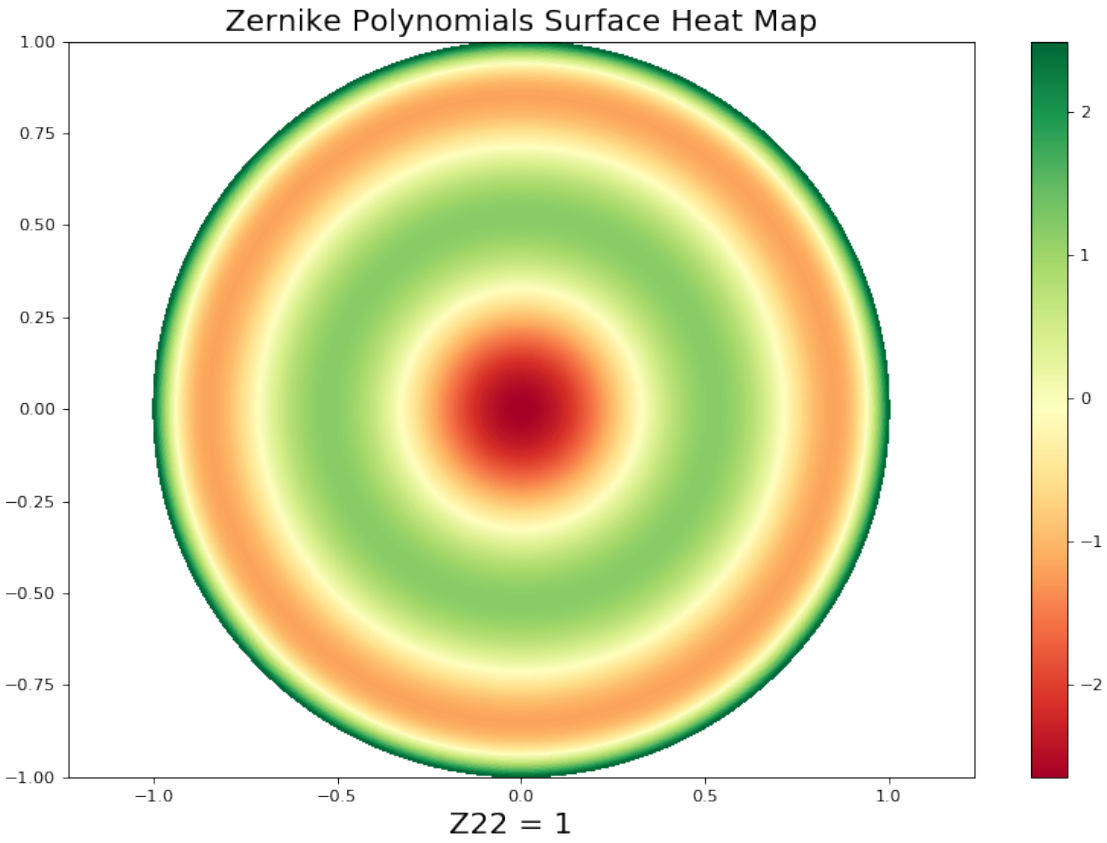


23

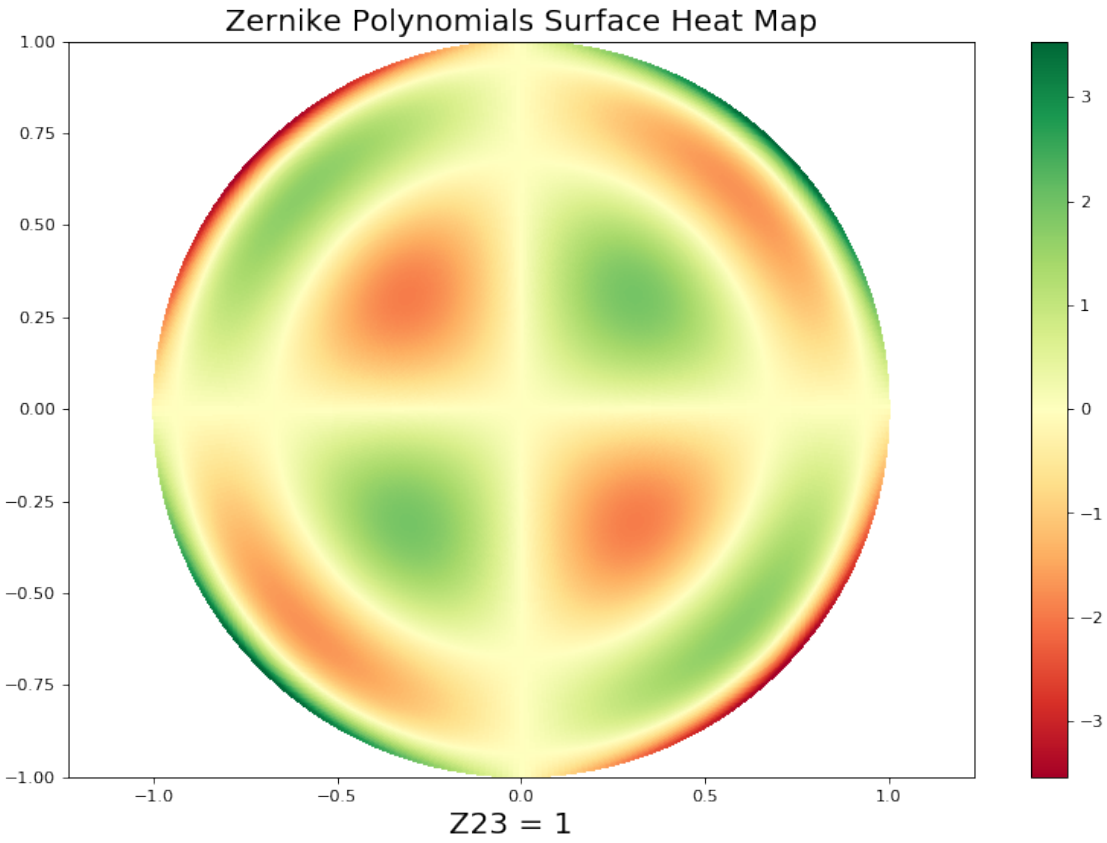
Z24 = 1 Z62 Tertiary Astigmatism at 0



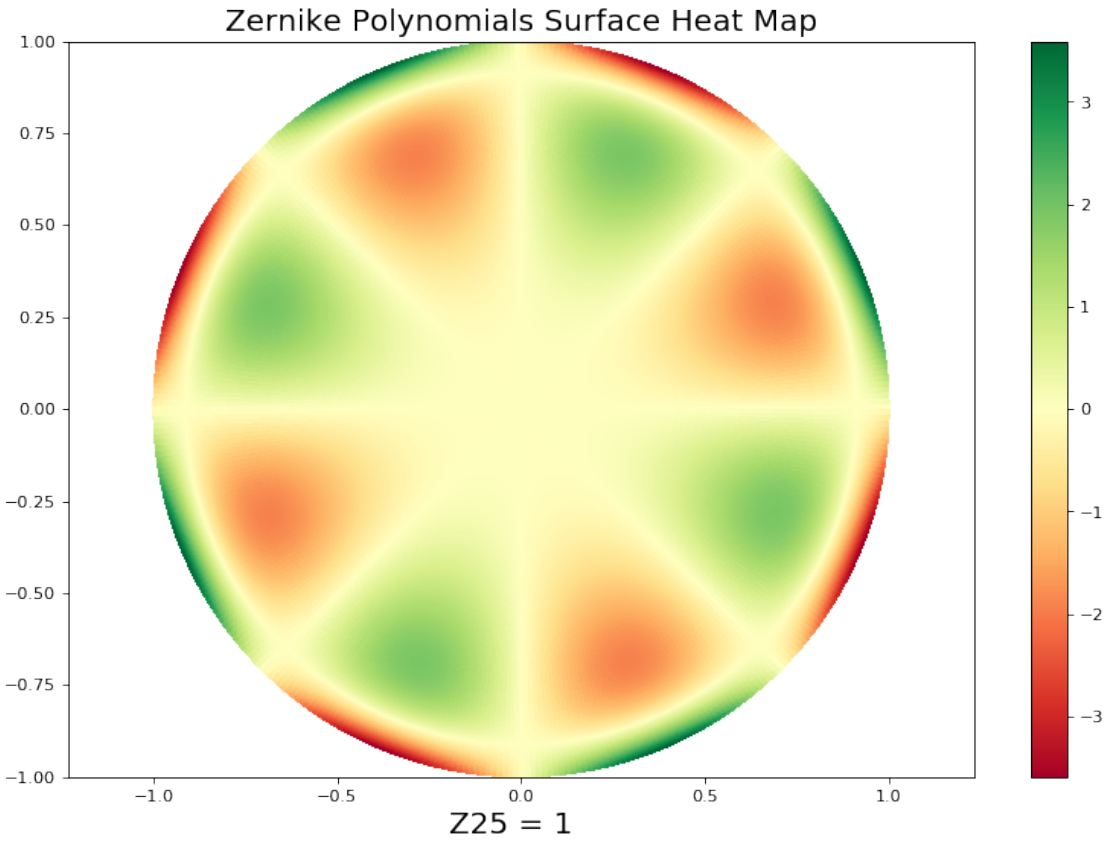

```
24
Z22 =  1 Z60 Secondary Spherical
```



25
Z23 = 1 Z62 Tertiary Astigmatism at 45

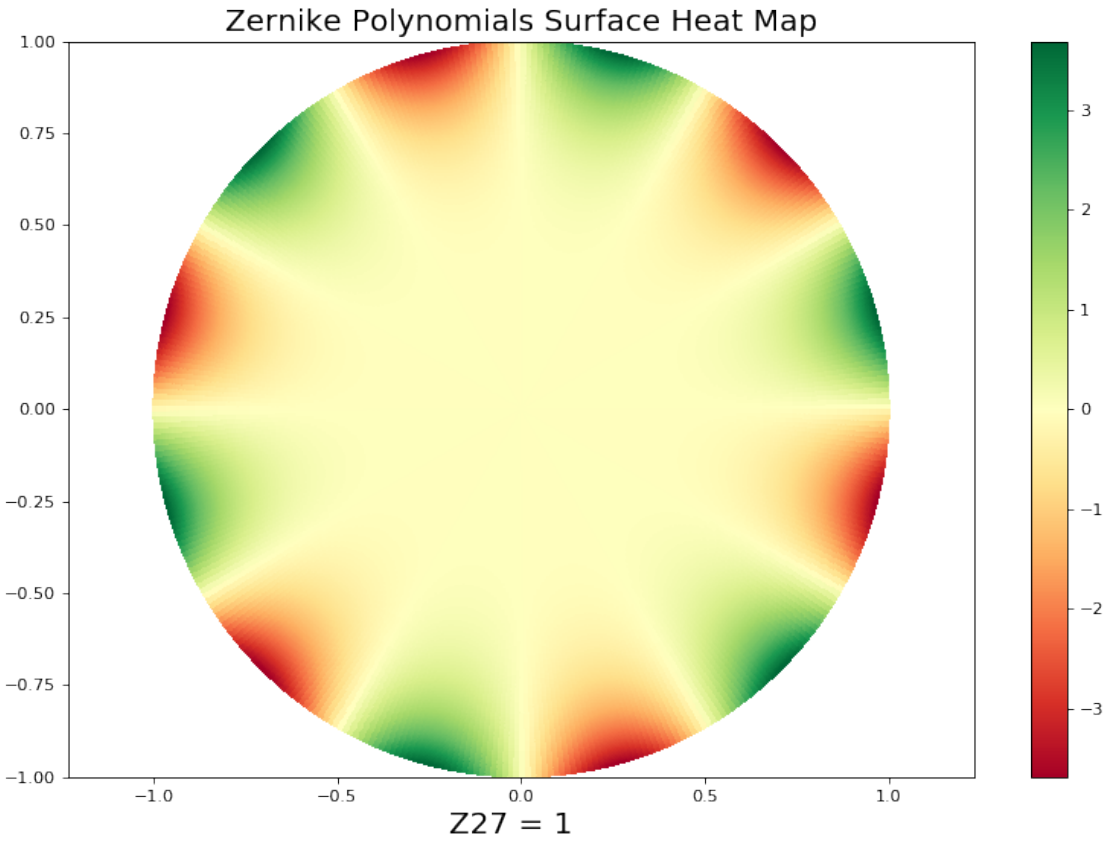


26
Z25 = 1 Z64 Secondary x Trefoil

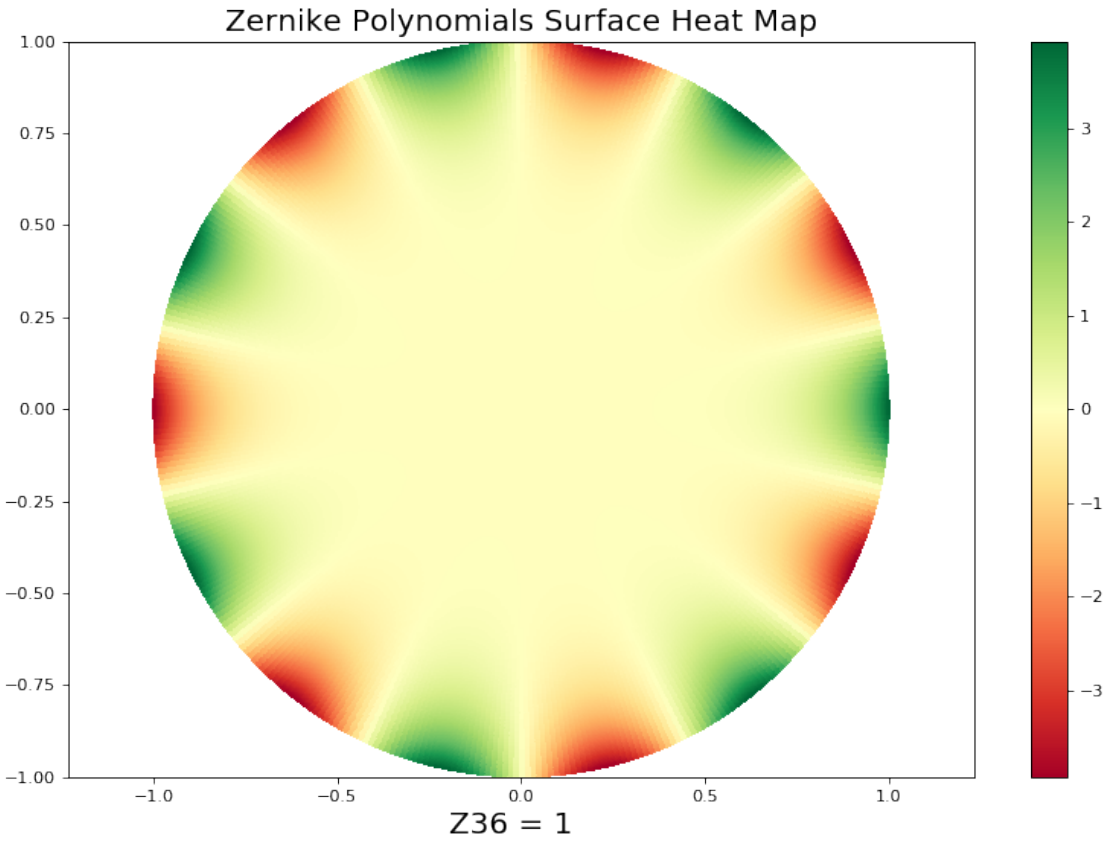


27

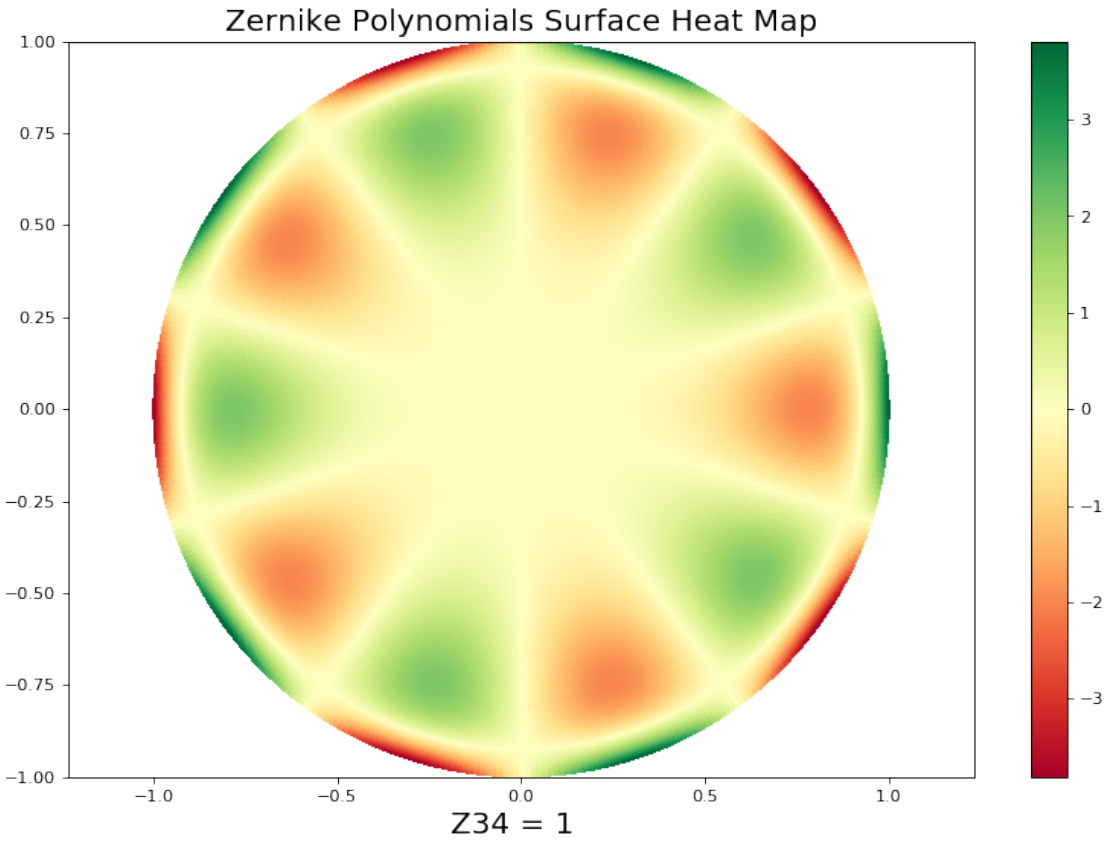
Z27 = 1 Z66 Hexafoil Y



28
Z36 = 1 Z77 Heptafoil X

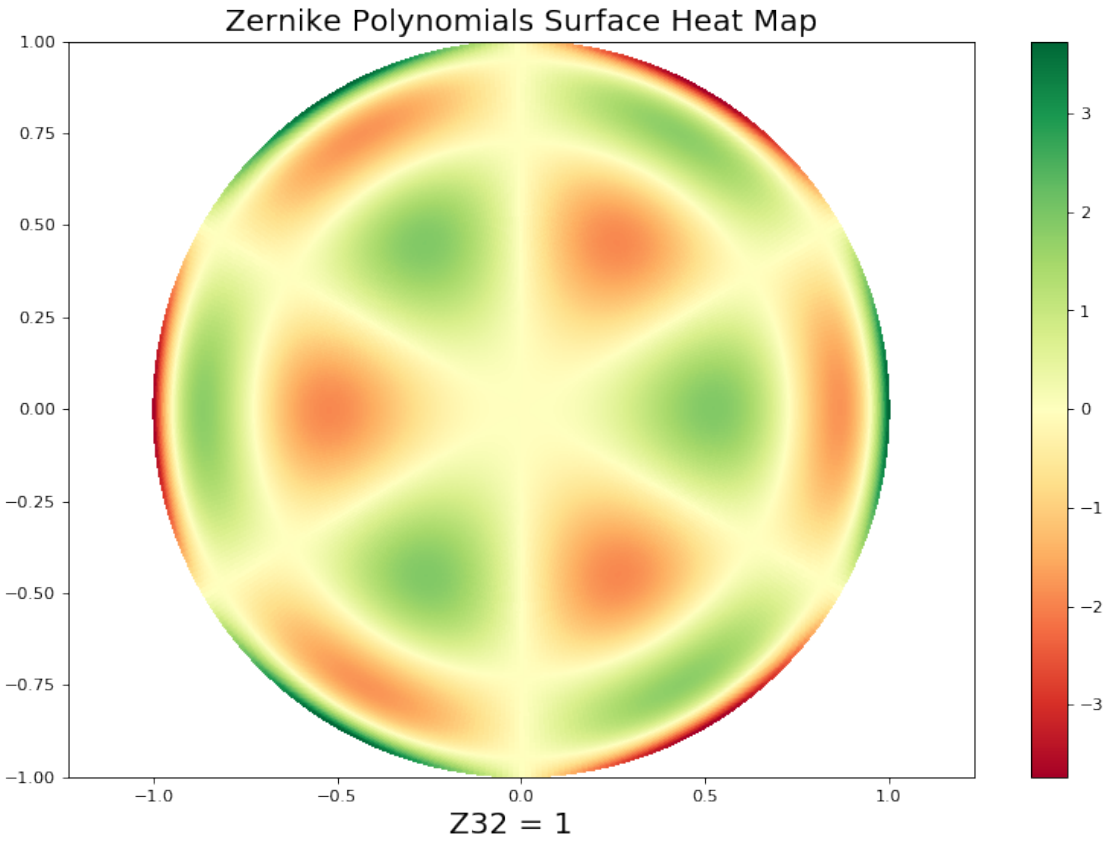


29
Z34 = 1 Z75 Secondary Pentafoil X

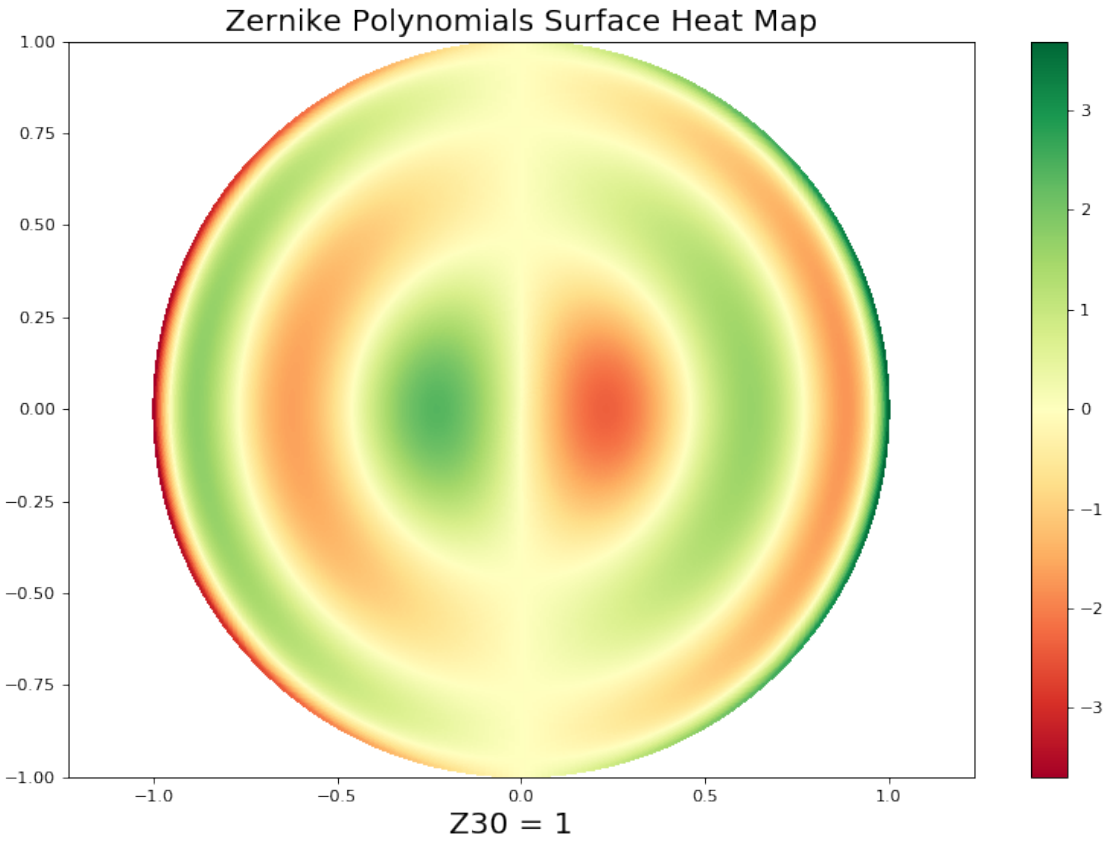


30

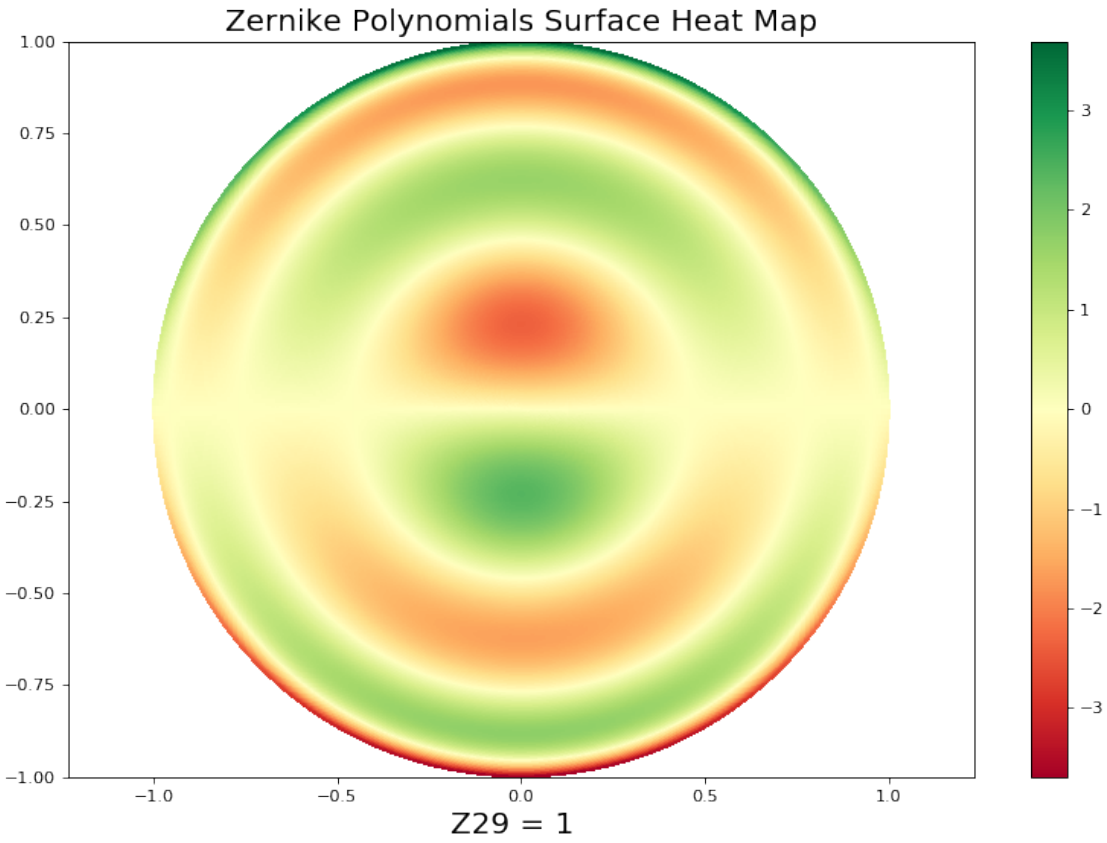
Z32 = 1 Z73 Tertiary x Trefoil



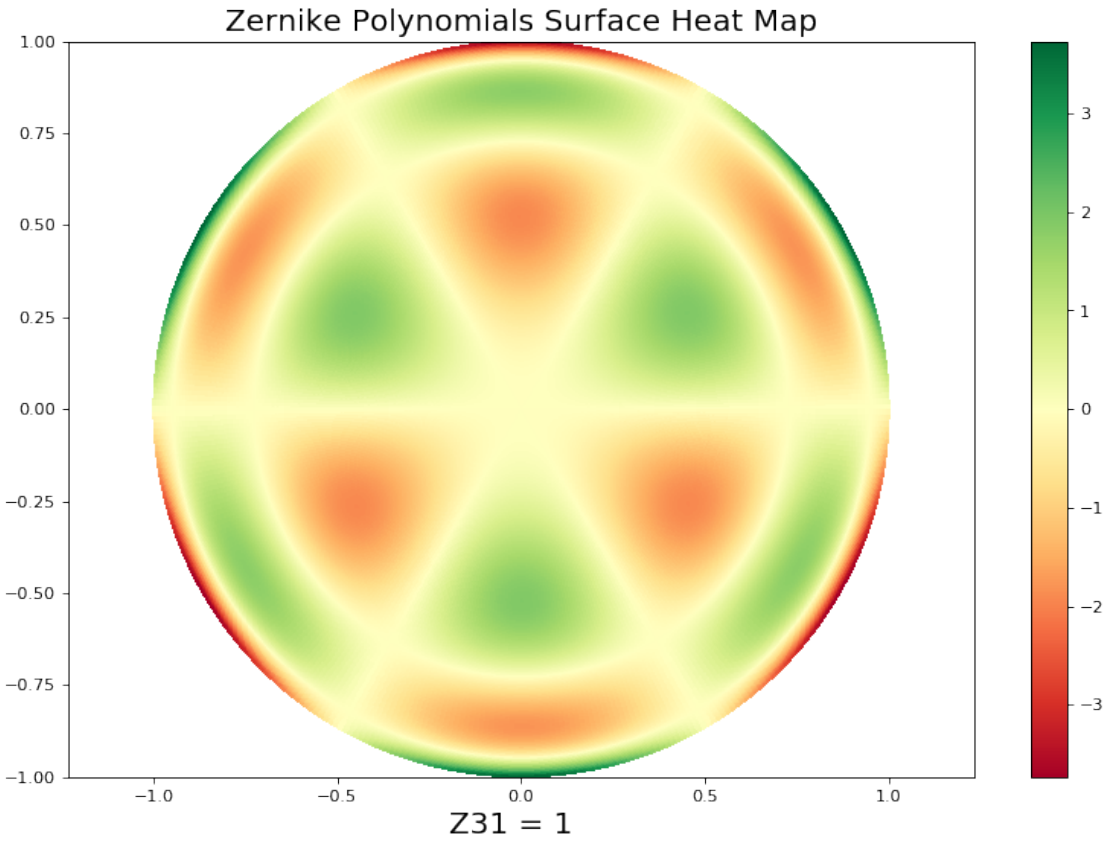
31
Z30 = 1 Z71 Tertiary x Coma



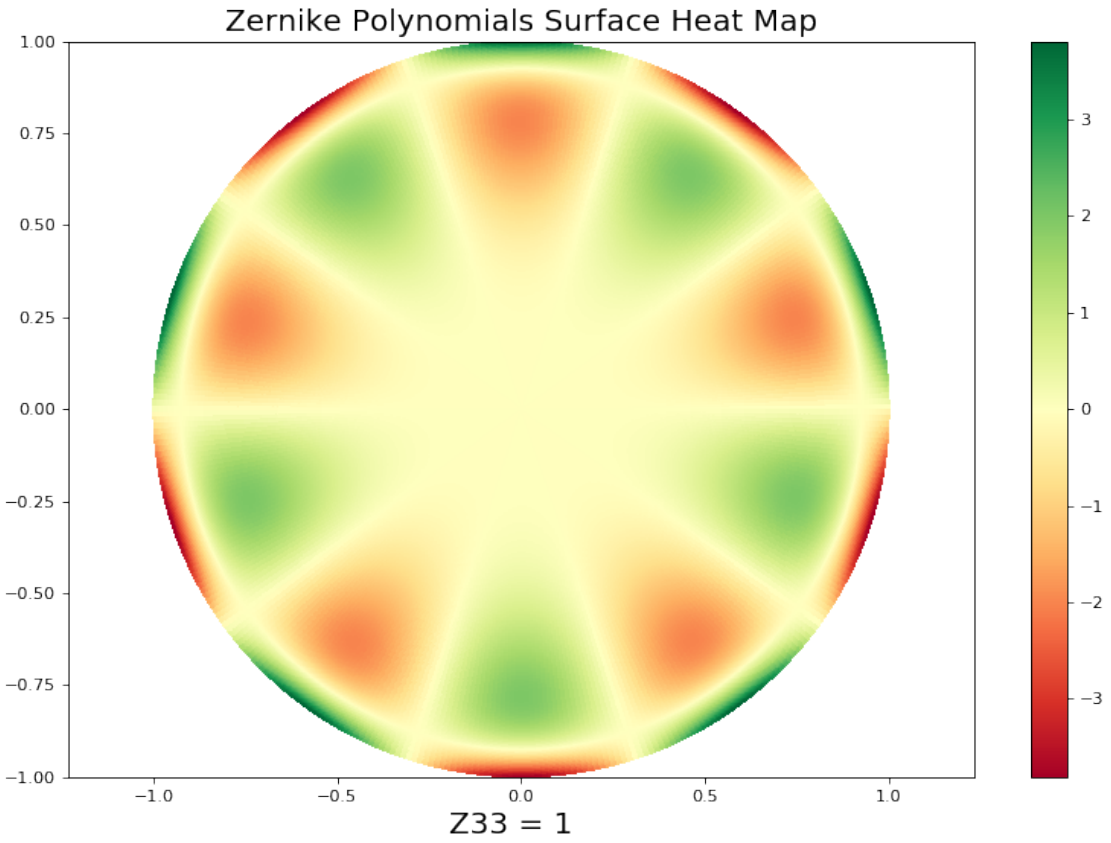
32
Z29 = 1 Z71 Tertiary y Coma



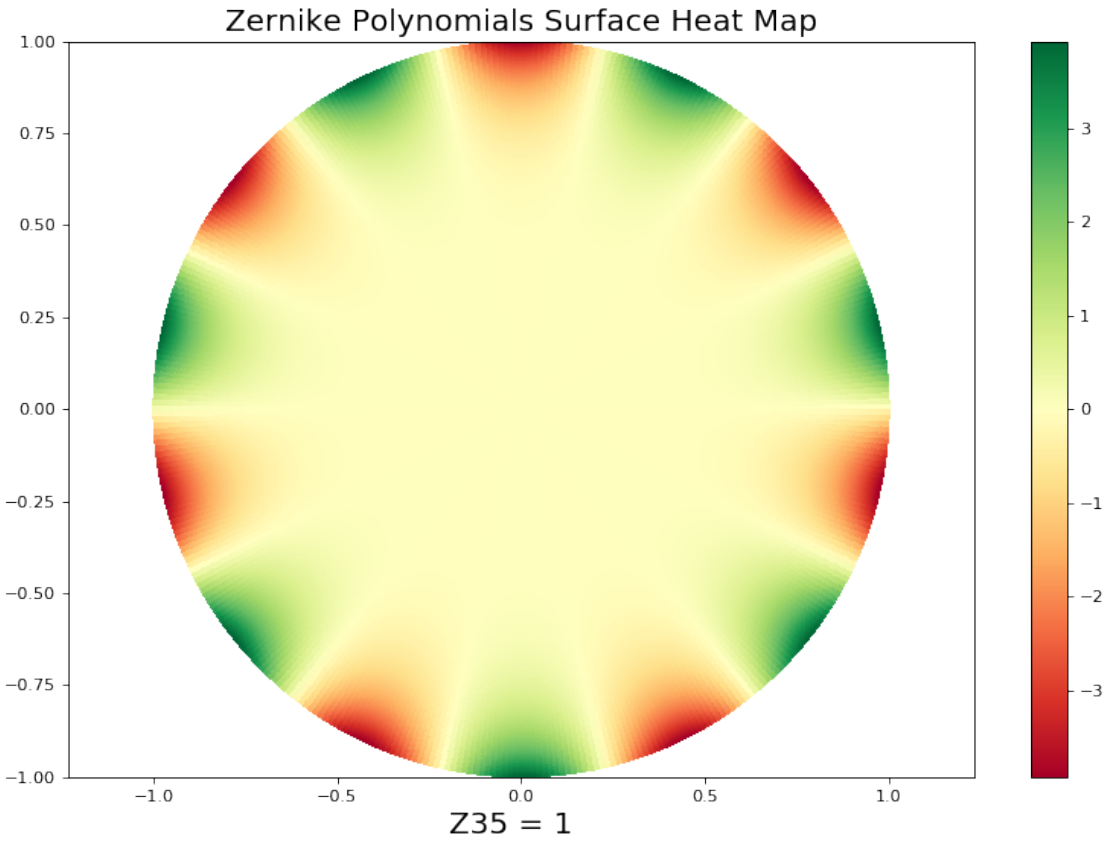
33
Z31 = 1 Z73 Tertiary y Trefoil



34
Z33 = 1 Z75 Secondary Pentafoil Y



35
Z35 = 1 Z77 Heptafoil Y



2 Make sure that it traverses the above pyrimad right to left

instead of left to right